Technical Memo

ANL/EES-TM-321

TRANSPORTATION ENERGY AND EMISSIONS MODELING SYSTEM (TEEMS):

CONFIGURATION FOR FORECASTING TRANSPORTATION-SOURCE EMISSIONS FOR THE 1985 TEST RUNS

ANL EES

ARGONNE NATIONAL LABORATORY

Energy and Environmental Systems Division

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by

Anant D. Vyas and Christopher L. Saricks

Energy and Environmental Systems Division

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FOREWORD

Under the auspices of the National Acid Precipitation Assessment Program (NAPAP), activities supporting the preparation of future assessments have been planned and delegated to task groups. Task Group B (TG-B), "Man-Made Sources" (subsequently redesignated Task Group I, "Emissions and Controls"), of the Interagency Task Force on Acid Precipitation is responsible for developing and testing models that can be used to project fuel use and air-pollutant emissions by energy use sector. Argonne National Laboratory (ANL) has participated in the TG-B program since 1984.

The TG-B program is being carried out in two phases. Phase 1 includes development of models for the generation of baseline scenarios. Phase 2 will address capabilities for modeling emission-control scenarios. Under Phase 1, sector models are being developed and tested. This testing is designed to aid in model development and help prepare the models for use by the task force. Upon completion, the sector models will be incorporated into the TG-B emission model set and linked to a system of models that will provide scenario-consistent input data.

The ANL Energy-Economic Modeling Program is publishing a series of reports that document the selection, development, and execution of two end-use sector models. This report is part of this series; it documents the steps undertaken to configure a modeling system for the transportation sector, called the Transportation Energy and Emissions Modeling System (TEEMS), for the purpose of generating test-case forecasts of emissions by pollutant category and state (in five-year intervals between 1985 and 2010 and in ten-year intervals to 2030). The report describes the development of the modeling system's transportation-activity input stream, the procedures used to convert this national-level activity to state-level emissions by source category, and the results of applying the system to three alternative economic-growth scenarios as part of the 1985 NAPAP testing program.

ACKNOWLEDGMENTS

This report became possible through the contributions of several individuals. P.D. Patterson of the U.S. Department of Energy (DOE) Office of Transportation Systems reviewed TEEMS demand-projection procedures and technological parameters on several occasions. This assistance resulted in improved modeling procedures and refined technological parameters. D.A. Hanson and D.W. South of Argonne National Laboratory provided essential energy-economic data for TEEMS. G.A. Boyd and D.A. Hanson answered several questions concerning the energy-economic driver data and provided projected data values beyond the year 2009. Finally, M.E. Millar provided valuable insight in contrasting TEEMS results with other, similar projections.

We thank R. Rykowski of the U.S. Environmental Protection Agency (EPA) Mobile Sources Laboratory in Ann Arbor, Michigan, for knowledgeable and incisive review of the discussion paper (No. 16) for NAPAP Task Group B that gave rise to the present document. For guidance and perceptive review throughout the project, H.W. Hochheiser of the DOE Office of Planning and Environment (Assistant Secretary for Fossil Energy), the principal sponsor of the work that produced the activity and emissions test results, is especially to be thanked. Also greatly appreciated is the past and present interest and support of D.O. Moses of the DOE Office of Environmental Analysis (Assistant Secretary for Environment) and P.D. Patterson, each of whom originally sponsored development of most of the discrete activity model components.

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ABSTRACT

As part of the model development and testing efforts of the National Acid Precipitation Assessment Program, the Transportation and Emissions Modeling System (TEEMS) was evaluated and tested for its ability to forecast emissions of acid-rain precursor pollutants. This report describes the testing of various TEEMS components. A discussion of the driver inputs for the activity projection modules is followed by a description of the regionalization and emissions-computation procedures. A base-case economic and demographic test scenario and two alternative scenarios are described. Results of activity- and emissions-forecasting model runs are presented, and the sensitivity of TEEMS components to demographic, economic, and technological changes is discussed.

1 INTRODUCTION

In the National Acid Precipitation Assessment Program (NAPAP), Task Group I (TG-I) is responsible for developing and testing models that can be used to project fuel use and air-pollutant emissions and control costs by energy-use sector. This work is being carried out in two phases. All activities described in this report have taken place under Phase 1 of the program, which includes development of models for the generation of baseline scenarios. This report describes the application of the Transportation Energy and Emissions Modeling System (TEEMS), one of the sector models developed by Argonne National Laboratory (ANL) for inclusion in the TG-I emissions model set (Fig. 1).[1] The TEEMS has been used in the preparation of test-case forecasts of transportation-source emissions under three hypothetical economic-growth scenarios for the period 1985-2030. These test-case forecasts were an important component of the 1985 NAPAP work program.

This introduction provides a brief overview of the emissions modeling and forecasting activities for mobile sources (transportation) required as part of the TG-I emissions-model-set activities under Phase 1. The needs and objectives of this transportation component of the model set are described. The remainder of the report presents the configuration of the TEEMS, in light of these objectives, for preparing projections of transportation-source emissions as a function of economic driver and demographic data (which give rise to discrete transportation activity patterns), state-

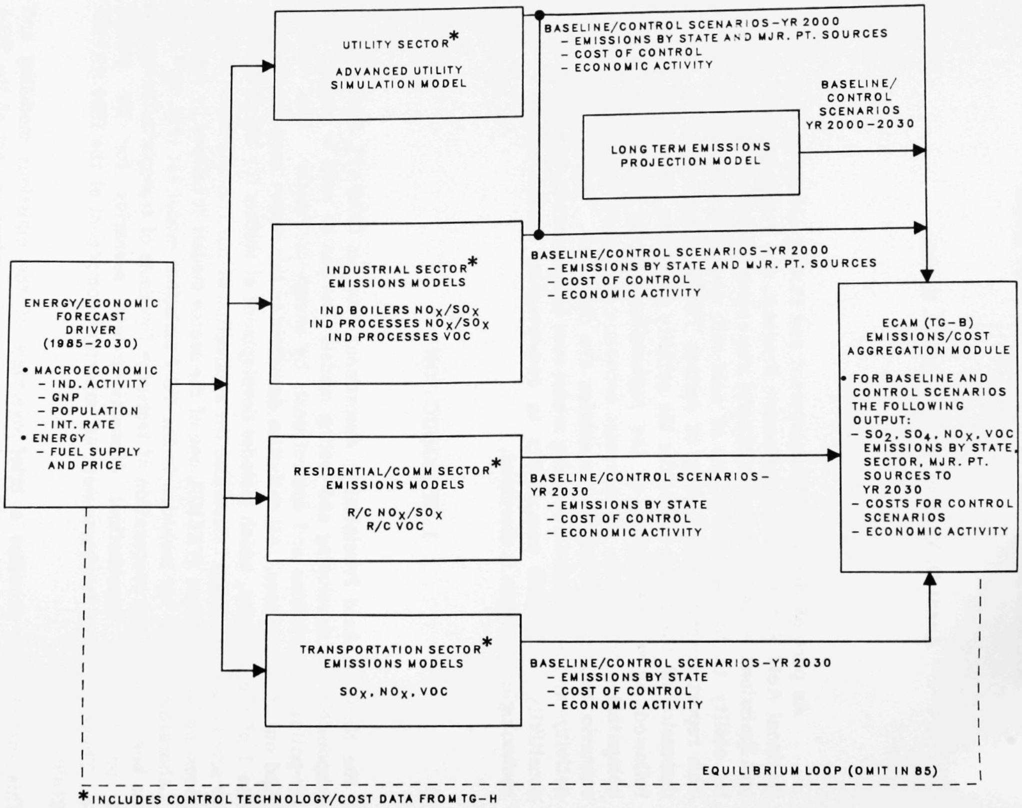

FIGURE 1 TG–I Emissions Model Set (Source: Ref. 1)

level activity allocation procedures, and region-specific climatological parameters. The results of applying TEEMS in this configuration to the 1985 test runs are described and interpreted.

1.1 BACKGROUND AND PURPOSE

The objectives for modeling transportation-source emissions in the TG-I emissions model set are as follows:

1. Develop an inventory of oxides of nitrogen (NO_x), volatile-organic-compound (VOC), and sulfur dioxide (SO_2) emissions arising from transportation activity in the continental United States for the years 1985, 1990, 1995, 2000, 2010, 2020, and 2030;

2. In the development of these inventories, employ forecasting and allocation techniques capable of estimating emission totals on a state-by-state basis; and

3. Incorporate within the forecasting scheme the ability to model the effects of currently programmed, planned, or potential vehicular emission-reduction strategies on the total pollutant loading (relative to a baseline projection), with particular attention to the date(s) of implementation of incremental controls and their expected stringency.

Figure 1 shows how this transportation emissions task fits into the general organizational scheme of the TG-I emissions model set. Figure 2 provides more detail on the place of this task within the forecasting scheme; all sector models are driven by a consistent set of energy and economic projections for the test runs planned in Phase 1.[1] The box in Fig. 2 representing TEEMS (the transportation emissions-forecasting component) could legitimately be partitioned into several discrete components of travel activity with respect to travel demand, modal (vehicular) share, and type of movement. These components are as follows:

- All local personal travel, both that occurring within Standard Metropolitan Statistical Areas (SMSAs), as defined in 1980, and other (non-SMSA) travel;

- Intercity personal travel by ground and air modes (business and nonbusiness);

- Commercial and rental automobile and light-truck travel;

- Interurban -- including port-to-port -- goods movement (coupled with intraurban distribution); and

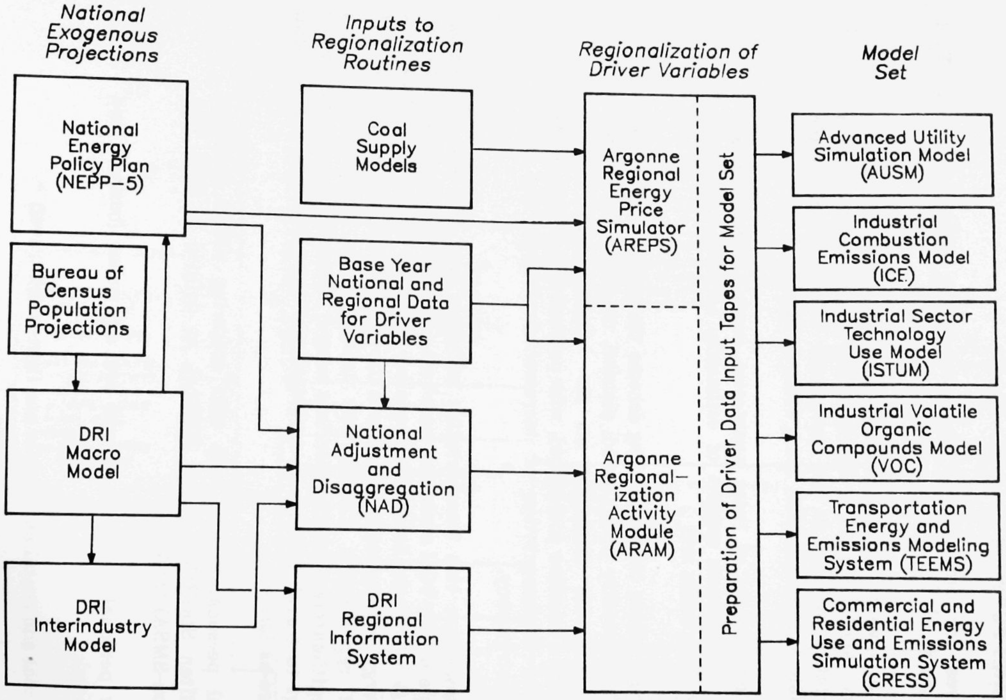

FIGURE 2 Details of Energy- and Economic-Forecast Driver for TG-I Emissions Model Set (Source: Ref. 1)

- Other aviation (including general, military, and international travel).

Because the demand for transportation service in any one of these cells may have only a weak dependence on -- or even virtual independence from -- the demand in any of the other cells, the approach to transportation forecasting within the emissions model set cannot be simplistic. Instead, the approach must account for all important differences in transportation activities, relying on the energy-economic driver to set the initial conditions for each component of the forecasting model. An earlier report described how the TEEMS met the requirements of such an approach.[1] The current document describes the application of the TEEMS within the framework of the 1985 NAPAP test runs, presenting both model configuration and results.

1.2 ORGANIZATION OF REPORT

Section 2 reviews the input data and related assumptions used in transportation-activity forecasting for the 1985 test runs. The economic and demographic driver information for each of the three TEEMS streams is presented first, followed by the specific methods and assumptions used to translate mode-specific activity outputs to emissions. Transportation modes are classified on the basis of whether their operation takes place on- or off-highway. The discussion in this section emphasizes input preparation for the test reference case; the high and low test cases (see Sec. 5) used an identical configuration, but with different values of the driver inputs.

Section 3 presents the state-level multipliers used to convert national projections to state-level totals of activity by mode for each forecast year. Empirical sources of data for the allocation procedure are also presented. Issues of spatial resolution with respect to climatological effects on emissions are also covered. Sections 4 and 5 present the results of the test reference-case run of TEEMS and the sensitivity test cases (high and low economic-growth scenarios) that were examined in 1985 under NAPAP auspices. Activity and emissions totals for the three cases are interpreted and compared in light of the input parameters and activity and energy-use forecasts developed from other models.

Acronyms and initialisms appear throughout this report. Where they are first used, the complete terms they represent are provided. In addition, all such acronyms and initialisms used in the text are listed, with their meanings, in App. A.

2 INPUT ASSUMPTIONS AND DATA FOR 1985 TEST RUNS: REFERENCE CASE

2.1 DRIVERS FOR TRANSPORTATION ACTIVITY

Activity modeling within TEEMS uses economic and demographic data, fuel prices, and technological information. For the 1985 test runs, a reference-case scenario representing middle-of-the-range economic and demographic projections and corresponding fuel prices was used. A draft National Energy Policy Plan 5 (NEPP-5) document provided demographic information concerning such matters as households and household sizes.[2] It also provided projections of fuel prices and future growth in energy commodities for use in the TEEMS freight-activity projections. A special run of the Data Resources, Inc. (DRI), macroeconomic forecasting model provided detailed economic forecasts corresponding to the draft NEPP-5 document.[3] Data Resources, Inc., also extended its macroeconomic forecasts to the NAPAP time horizon of 2030.[4] This economic, demographic, and fuel-price information was supplemented by ANL and the U.S. Department of Energy (DOE) with information on vehicle technology, projections of freight modal operational improvements, and intercity travel network structure.

2.1.1 Personal Travel

National totals for population and households were obtained from NEPP-5 output tables. Since NEPP-5 does not provide information beyond the year 2010, projections consistent with those based on the NEPP-5 document were obtained from DRI. Macroeconomic forecasts by DRI and their long-term extension provided information on personal income and number of workers. Tables 1 and 2 present this demographic information for the reference case.[2-5] Median household income was estimated using the historical relationship between personal income and median income.

The aggregate data in Table 1 were used to develop the distribution of households by key demographic parameters (see Table 3). The 1980 data in Table 3 represent data from the Bureau of the Census.[5] National data from Table 1 and projected demographic trends[2,3,6] were used to develop distributions of households for 1990 and beyond. Household distributions for two parameters, age and education of the head of household, were kept unchanged from an earlier travel activity projection effort.[7,8]

Light-duty vehicles (LDVs) were characterized using a technology data base available at ANL.[9] This data base is a revised version of the vehicle-characteristics data reported for DOE's TAPCUT (Technology Assessment of Productive Conservation in Urban Transportation) project.[10-12] The projected price of fuel for the existing technologies was evaluated in light of the vehicle technologies most likely to be marketed. The NEPP-5 draft, which projects lower fuel prices than have earlier NEPPs, predicts that the price of diesel fuel will exceed the price of gasoline by 1990. The rate of increase in diesel fuel price beyond the year 1990 is also projected to be greater than that for gasoline. The projected prices range from \$1.36 to \$3.04/gal for gasoline and from \$1.23 to \$3.54/gal for diesel fuel. Year-by-year fuel prices are listed in Table 4.

TABLE 1 Key Demographic Data — Reference Case[a]

Parameter	Parametric Values by Year					
	1980	1990	2000	2010	2020	2030
Population (10^6)	227.0	251.0	268.8	283.0	300.4	311.9
Households (10^6)	80.4	91.4	101.5	110.3	119.8	126.3
Average household size[b]	2.73[c]	2.68	2.59	2.51	2.46	2.42
Personal income ($\$10^9$)[d]	2,502.30	3,389.68	4,317.42	5,459.15	6,536.31	7,710.34
Median income ($)[e,f]	21,560	23,930	26,170	29,190	31,360	34,260
Number of workers[d] (10^6)	99.30	117.04	128.05	140.30	144.95	150.73
Average workers per household	1.235	1.281	1.262	1.272	1.210	1.193

[a]Data from NEPP-5 and the long-term extension unless otherwise noted. The long-term extension provided inputs beyond 2009.

[b]Excluding persons in group quarters (institutions). Number of persons in group quarters remains constant at 5.8 million.

[c]1980 Census figure.

[d]DRI projections and long-term extension (Refs. 3 and 4).

[e]Estimated from historical relationship between personal income and median income.

[f]1982 dollars.

TABLE 2 Average Annual Changes in Key Demographic Data — Reference Case[a]

Parameter	Average Annual Change (%) 1980-2000	2000-2030
Population	0.85	0.50
Households	1.17	0.73
Average household size	-0.26	-0.23
Personal income	2.76	1.95
Median income	0.97	0.90
Number of workers	1.28	0.55
Average workers per household	0.11	-0.19

[a]Percentages determined on the basis of parametric values given in Table 1.

If fuel prices are lower, expensive technologies will not significantly penetrate the market. Past experience with TEEMS has shown that, under these circumstances, such technologies will have only a negligible effect on results. Therefore, Otto-cycle engines and diesel engines were the only technologies considered for household vehicles. Seven household vehicles were characterized, including Otto and diesel minivans, as shown in Table 5. Vehicle operating costs listed in Table 5 include the cost of fuel, which was computed using the NEPP-5 fuel prices. Household vehicle characteristics and a 1980 automobile ownership distribution were used to estimate the future household automobile and minivan ownership probabilities. The share of diesel trucks among personal light trucks was assumed to increase through 2010 and then to decline as a result of higher diesel fuel price. The share of diesel trucks was assumed to be 2.6% in 1990, 4.1% in 2000, 7.7% in 2010, and 6.9% in 2020-2030.

2.1.2 Freight Movement

Estimates of the base-year ton-miles of travel (TMT) by commodity sector have been made earlier by ANL.[7,13] Several sources were used to compile this information. The Federal Railroad Administration's 1% waybill sample,[14] the U.S. Corps of Engineers' data on marine freight movements,[15] the Truck Inventory and Use Survey (TIUS) of 1977,[16] the Commodity Transportation Survey (CTS) of 1977,[17] U.S. Department of Agriculture and Census Bureau data on farm products and minerals,[18,19] the Association of Oil Pipelines' data on oil and petroleum product movement, and historical information on natural gas consumption were all used to develop the base-year freight-movement

TABLE 3 Distribution of Households within Key Demographic Parameters — Reference Case (%)

Parameter	Distribution by Year					
	1980[a]	1990	2000	2010	2020	2030
Location						
Urban[b]	68.3	67.8	67.5	67.5	67.5	67.5
Rural	31.7	32.2	32.5	32.5	32.5	32.5
Income[c]						
Low (<$15,000)	63.2	61.4	56.8	50.3	46.5	42.3
Middle ($15-25,000)	23.5	24.1	26.5	28.9	30.8	33.2
High (>$25,000)	13.3	14.5	16.7	20.8	22.7	24.5
Household size						
1	22.7	23.3	24.2	25.1	25.6	26.1
2	31.3	31.5	32.3	33.3	34.1	34.7
3-4	33.2	34.1	34.9	34.9	34.8	34.2
5 or more	12.8	11.1	8.6	6.7	5.5	5.0
Education of head of household						
< High school	32.2	20.8	13.2	8.4	8.4	8.4
High school graduate	33.9	36.2	36.8	35.7	35.7	35.7
Some college	15.6	19.1	21.9	23.7	23.7	23.7
College graduate	18.3	23.9	28.1	32.2	32.2	32.2
Workers per Household						
0	25.2	25.6	26.6	26.9	29.8	30.0
1	37.6	31.5	28.7	26.7	24.3	25.0
2	29.0	35.2	38.9	40.9	42.4	42.0
3+	8.2	7.7	5.8	5.5	3.5	3.0
Age of head of household						
<25 years	8.1	7.8	6.5	6.5	6.5	6.5
25-34 years	22.6	20.5	19.1	19.1	19.2	19.2
35-44 years	17.6	21.9	17.6	16.6	16.6	16.6
45-54 years	15.9	15.5	21.2	15.2	16.3	16.2
55-64 years	15.4	12.4	14.1	20.2	13.4	13.4
65 years or more	20.4	21.9	21.5	22.4	28.0	28.1

[a]Source: Refs. 5 and 6.

[b]Percent of households located in any of the 266 SMSAs designated by the Bureau of Economic Analysis in 1977.

[c]In 1975 dollars. Converted to 1982 dollars, the income classes are as follows: low, <$26,927; middle, $26,927-44,877; and high, >$44,877.

TABLE 4 Gasoline and Diesel Retail Prices — Reference Case

Year	Gasoline		Diesel Fuel	
	Pump Price ($/gal)[a]	Average Annual Change (%)	Pump Price ($/gal)[a]	Average Annual Change (%)
1980	1.52	-	1.23	-
1990	1.36	-1.11	1.43	1.52
2000	1.72	2.38	1.89	2.83
2010	2.22	2.58	2.52	2.92
2020	2.63	1.71	3.03	1.86
2030	3.04	1.46	3.54	1.57
1980-2030	-	1.40	-	2.14

[a]1984 dollars.

information. Table 6 shows the base-year (1977) TMT by commodity sector and mode. Rail, water, air, and pipeline totals agree with published estimates. The truck total exceeds published estimates because it includes some local pickup and delivery movements. In addition to the truck TMT reported in Table 6, certain sectors in which no commodity is carried use trucks; the use of commercial trucks in such sectors is better measured in terms of vehicle-miles of travel (VMT). The base-year activities (10^9 VMT) for four such sectors were estimated as follows: retail trade, 18.60; utilities, 5.94; services, 37.56; and construction, 26.97.

Future-year TMT were estimated on the basis of expected growth in each commodity sector for each 10-year interval between 1990 and 2030. Growth indexes shown in Table 7 were developed from the following sources: NEPP-5 forecasts of energy supply, DRI's macroeconomic forecasts, long-term extension data, known transportation-related information (such as availability of Alaskan oil between 1977 and 1980), and forecasts of increased use of western coal and increased use of natural gas as fuel for gas pipeline transmission.[20] Table 7 also shows the variables or other indicators used to arrive at these indexes.

In anticipation of technological improvements that will influence transportation activity, rail and truck freight operations were defined to improve their line-haul (over-the-road) travel times. The recent deregulation of freight transportation has created multimodal movement capability within a carrier. Railroad mergers and increased use of unit trains are expected to contribute to improved rail line-haul time and reliability. Rail line-haul time is assumed to decline to 80% of the 1972 time in 1990 and stabilize at 70% of the 1972 line-haul time by the year 2000. Truck line-haul time is expected to rise 12% over the 1972 line-haul time, due to the lower speed limit on the interstate system. Commercial trucks are expected to include a larger share of diesel trucks and carry heavier payloads. Table 8 presents the expected diesel market penetration by size class.

TABLE 5 Characteristics of Household Vehicles — Reference Case

		Automobiles					Minivans	
		Otto Cycle						
Year	Characteristic[a]	Mini[b]	Small	Medium	Large	Diesel	Otto Cycle[c]	Diesel[d]
1990	Curb wt. (lb)	1,920	2,135	2,810	3,405	3,055	3,340	-
	Horsepower	72	80	102	120	102	128	-
	Price ($)[e]	2,840	3,220	4,030	5,110	4,565	7,930	-
	Operating cost (¢/mi)[e]	11.0	11.9	14.2	16.7	14.0	16.2	-
2000	Curb wt. (lb)	1,625	1,845	2,435	2,990	2,565	3,265	3,315
	Horsepower	67	75	96	116	102	125	127
	Price ($)[e]	2,960	3,320	4,255	5,455	4,815	6,910	9,980
	Operating cost (¢/mi)[e]	11.1	12.2	14.6	17.1	14.4	17.7	16.9
2010	Curb wt. (lb)	1,590	1,810	2,390	2,895	2,475	3,155	3,300
	Horsepower	66	73	95	112	97	121	126
	Price ($)[e]	3,065	3,410	4,425	5,725	4,965	7,285	7,920
	Operating cost (¢/mi)[e]	12.4	13.5	16.3	19.2	15.9	20.0	19.2
2020	Curb wt. (lb)	1,570	1,780	2,355	2,855	2,440	3,120	3,265
	Horsepower	65	73	95	110	96	119	125
	Price ($)[e]	3,165	3,495	4,580	5,940	5,110	7,600	8,230
	Operating cost (¢/mi)[e]	13.2	14.3	17.3	20.4	16.8	21.6	20.6
2030	Curb wt. (lb)	1,570	1,780	2,355	2,855	2,440	3,120	3,265
	Horsepower	65	73	95	110	96	119	125
	Price ($)[e]	3,265	3,580	4,835	6,165	5,260	7,925	8,555
	Operating cost (¢/mi)[e]	14.2	15.5	18.8	22.1	18.1	23.5	22.4

[a]Based on age-weighted average of vehicles (MOBILE3 age distribution used).

[b]Introduced in 1981.

[c]Introduced in 1984.

[d]Assumed year of introduction is 1993.

[e]Based on 1984 dollars.

TABLE 6 Base-Year (1977) Ton-Miles by Mode and Commodity Sector (10^9 ton/mi)

STCC[a]	Commodity Sector	Rail	Water	Truck	Air	Pipeline	Total
01	Farm products	79.45	53.36	84.36[b]	2.19	-	219.37
08,09	Forestry/fishery products	0.83	1.52	0.28	0.08	-	2.72
10,40	Metallic ores	31.73	38.61	4.45[b]	-	-	74.79
11,12	Coal	198.42	46.29	23.15[b]	-	-	267.86
13	Crude petroleum	1.11	63.48	-	-	326.60	391.19
14	Nonmetallic minerals	47.77	32.21	88.73	-	-	168.71
20	Food products	94.04	20.36	81.58	0.09	-	196.07
22,23	Textiles/apparel	1.52	0.24	8.11	0.12	-	9.99
24	Lumber/wood products	68.47	3.58	35.92	--[c]	-	107.97
26	Pulp/paper products	55.26	1.52	18.59	0.02	-	75.39
28	Chemicals	99.01	47.03	49.48	0.08	-	195.60
29	Petroleum/coal products	29.28	273.25	10.28	--[c]	219.40	532.21
32	Clay/concrete/glass	36.72	4.82	41.83	0.02	-	83.39
33	Primary metal products	39.16	9.20	32.67	0.06	-	81.09
34	Fabricated metal products	3.43	0.80	17.05	0.09	-	21.37
35	Nonelectric machinery	3.52	0.36	11.01	0.26	-	15.15
36	Electric machinery	3.36	0.47	7.17	0.20	-	11.20
37	Transportation equipment	34.05	0.97	11.65	0.38	-	47.05
--[d]	Miscellaneous manufactures[e]	6.90	0.91	34.76	0.35	-	42.92
	Natural gas	-	-	-	-	225.78	225.78
	Total, all commodities	834.03	598.98	561.07[f]	3.95	771.78	2769.81[g]

[a]Standard Transportation Commodity Classification; generally equivalent to SIC (Standard Industrial Classification) code.

[b]Includes some truck pickup and delivery of rail and water hauls.

[c]Less than 0.01.

[d]Sectors 21, 25, 27, 30, 31, and 38.

[e]Includes imports.

[f]Includes some local pickup and delivery.

[g]Excluding natural gas.

Average truck load estimates for the base year were obtained from the 1977 Truck Inventory and Use Survey and the Federal Highway Administration's (FHWA's) Highway Cost Allocation Study. Payloads were computed by commodity sector using registered and empty weights and then adjusting mean payloads to reflect partial loading and empty backhauls based on field surveys.[21,22] The average load factors in Table 9 reflect extensive use of smaller trucks for some commodities, such as agricultural products, and take into account the density of the commodity. The density factor results in some commodities having low payload weights, because they quickly exceed the truck's volume limit. These low payloads will continue to affect some commodities, even after accounting for the recent increase in load limits.

Table 10 shows the split of marine TMT among the coastal, inland, and Great Lakes areas. The increase in coastal share between 1977 and 1980 is due to Alaskan oil; this trend is expected to continue. Increases in commodity TMT are reflected in the growth indexes presented in Table 7.

TABLE 7 Ton-Miles Growth Indexes by Commodity Sector, 1980-2030 (1977 = 1.00) — Reference Case

Commodity Sector	1980	1990	2000	2010	2020	2030	Indicator(s)[a]
Farm products	1.152	1.523	2.184	2.820	3.499	4.098	Food products production, agricultural exports
Forestry/fishery products	0.910	1.402	1.630	1.994	2.101	2.147	Lumber and wood products production
Metallic ores	1.111	1.532	1.909	2.353	2.390	2.266	Mining production, excluding oil and natural gas
Coal	1.303	1.939	3.055	4.946	5.576	6.683	Coal production[b]
Nonmetallic minerals	1.111	1.532	1.909	2.353	2.390	2.266	Mining production, excluding oil and natural gas
Crude petroleum	1.920	1.875	1.864	1.841	1.819	1.819	Primary oil consumption[b]
Food products	1.079	1.381	1.698	2.058	2.417	2.806	Food and kindred products production
Textiles/apparel	1.000	1.309	1.499	1.784	1.987	2.178	Textiles production, apparel production
Pulp/paper products	1.099	1.446	1.710	2.004	2.247	2.480	Paper products production[c]
Chemicals	1.116	1.491	1.885	2.339	2.805	3.294	Chemicals production[c]
Petroleum/coal products	0.932	0.910	0.905	0.894	0.883	0.883	Petroleum liquids supplied[b]
Stone, clay, and glass products	1.015	1.417	1.788	2.258	2.588	2.903	Stone, clay, and glass production
Primary metal products	0.919	1.215	1.416	1.683	1.710	1.666	Primary metal production[c]
Fabricated metal products	1.024	1.457	1.886	2.490	2.987	3.491	Fabricated metal production, ordnance production
Nonelectric machinery	1.134	2.048	3.017	4.185	4.958	5.592	Machinery (excluding electric) production
Electric machinery	1.189	2.205	3.088	4.191	4.942	5.582	Electric machinery production
Transportation equipment	0.954	1.597	2.070	2.756	3.132	3.418	Transportation equipment production
Miscellaneous manufactures	1.070	1.929	2.729	3.945	5.027	6.110	Production of rubber and miscellaneous plastics, furniture, instruments, and "other" products.
Retail trade	1.001	1.398	1.751	2.207	2.607	3.028	Production of consumer goods
Utilities	1.075	1.352	1.460	1.624	1.662	1.669	Utilities production
Services	1.117	1.490	1.877	2.355	2.841	3.377	Services expenditure
Construction	1.132	1.432	1.543	1.830	2.069	2.339	Construction employment
Natural gas	1.191	1.167	1.119	1.000	0.924	0.907	Natural gas supplied[b]

[a]Except as noted, all indicators are from the DRI macroeconomic forecasts, with 2010-2030 values from DRI long-term extension.

[b]NEPP-5 forecast for 1990-2010 and long-term extension of these variables prepared by DOE Policy Office. All coal-production growth over 1980 production is assumed to be in western coal. NEPP-5 coal tonnages are modified by an increase in average length of haul.

[c]DRI forecasts for these indicators were reduced by ANL to reflect slower growth of physical output than growth in industrial production indexes: Paper, -0.6% (per year) in 1980-2009 and -0.4% thereafter; Chemicals, -1.8% in 1980-2009 and -1.4% thereafter; and Primary Metals, -0.5% in 1980-2009 and -0.3% thereafter (Ref. 20).

TABLE 8 Diesel Share of Truck Stock by Size Class, 1977-2030 (%)

Size class[a]	1977	1980	1990	2000	2010	2020	2030
Light (class 1-2)	0.4	0.8	5.8	13.7	20.5	18.9	18.9
Medium (class 3-5)	1.4	1.8	8.5	36.0	54.0	60.0	60.0
Light-heavy (class 6)	5.0	10.0	46.5	77.5	88.5	90.0	90.0
Heavy-heavy (class 7-8)	75.3	83.0	95.5	99.2	100.0	100.0	100.0

[a]On the basis of manufacturer's weight class.

TABLE 9 Average Truck Loads by Commodity Sector, 1977 and 2030

Commodity Sector	Truck Load[a] (TMT/VMT) 1977	Truck Load[a] (TMT/VMT) 2030[b]	Commodity Sector	Truck Load[a] (TMT/VMT) 1977	Truck Load[a] (TMT/VMT) 2030[b]
Farm products	3.0	3.3	Clay/concrete/glass	10.0	11.1
Forestry/fishery products	3.4	3.4	Primary metal products	11.7	12.6
Metallic ores	5.8	6.2	Fabricated metal products	7.4	8.4
Coal	5.8	6.2	Nonelectric machinery	8.8	8.8
Nonmetallic minerals	5.8	6.2	Electric machinery	5.7	6.5
Food products	8.2	9.4	Transportation equipment	6.8	6.8
Textiles/apparel	10.5	10.5	Miscellaneous manufacturers	10.7	10.7
Lumber/wood products	8.4	9.1			
Pulp/paper products	5.6	6.0			
Chemicals	6.5	7.0			
Petroleum/coal products	2.7	2.9			

[a]In operation (i.e., accounting for part loadings, empty backhauls, and the distribution of hauls by truck sizes). Numbers shown for 1977 were calculated from tonnage and total VMT data and differ substantially from loadometer and "weighed-in-motion" data.

[b]Same loads assumed for 2020 and 2030.

2.1.3 Intercity Travel

State-level projections by DRI of population and employment and SMSA-level projections by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA)[23] were used to develop inputs for the POINTS (Passenger-Oriented Intercity Network Travel Simulation) model, which projects intercity travel and mode share for 142 consolidated metropolitan areas. The POINTS model uses population, employment, government employment, and hotel/motel receipts as a fraction of total commercial receipts. For this analysis, information relating to modes and hotel/motel share of total receipts were kept the same as in an earlier ANL effort.[13] Each consolidated metropolitan area's composition was computed in terms of its share of state-level activity using BEA's SMSA- and state-level projections. Government employment was estimated as a fraction of total employment. These shares were then applied to DRI's state-level projections to develop the POINTS inputs (see Ref. 1, p. 32).

TABLE 10 Marine Ton-Miles by Area of Operation, 1977-2030 (%)[a]

	Area of Operation		
Year	Coastal	Inland	Great Lakes
1977	57.4	33.9	8.7
1980	68.6	24.7	6.7
1990	69.5	24.0	6.5
2000	70.0	23.6	6.4
2010	70.5	23.2	6.3
2020	71.0	22.8	6.2
2030	71.0	22.8	6.2

[a]Total for coastal, inland, and Great Lakes areas equals 100% in any year.

2.2 CONVERSION OF ACTIVITY TO EMISSIONS

2.2.1 On-Highway Sources

The TEEMS activity categories included among highway emission sources are (1) personal travel in gasoline- and diesel-powered (light-duty) automobiles and trucks, and (2) commercial travel (movement of raw and manufactured goods and travel in performance of services) by light- and heavy-duty gasoline- and diesel-powered trucks. Each type of travel is considered separately below.

2.2.1.1 On-Highway Personal Travel

On-highway personal-travel annual VMT by cars and light trucks are generated directly by TEEMS for each forecast year; this output is fully consistent with the requirements of the EPA emission-factor models MOBILE3 and AP-42 (for SO_2),* as described in Ref. 1 (see App. B). The Disaggregate Personal Transportation Activity Module (DPTAM), as explained in Ref. 1, produces a forecast of total personal VMT, from which the intercity (long-distance, high-speed) component must be subtracted to separate this VMT into distinct speed-related components for purposes of emissions factoring. Intercity VMT by state is produced directly by POINTS. Commercial truck VMT by size class is produced by FRATE3 (Freight-Responsive Accounting for Transportation Energy, Version 3). For light trucks, VMT are added to national totals for personal travel (gasoline power only) prior to allocation. National-level VMT from DPTAM are preallocated to states (according to the fractional multipliers shown in Sec. 3). Subsequently, state VMT from POINTS are subtracted from the allocated totals for car and light-truck VMT, because some intercity personal travel is performed by light trucks. At this point, for each state, the following will have been determined: (1) local travel by automobile, (2) intercity travel by automobile, (3) local travel by light trucks and vans (emission categories LDGT and LDDT in MOBILE3),‡ and (4) intercity travel by light trucks and vans. The split by fuel type for this travel is provided by DPTAM. This completes input data preparation for the LDV and LDT categories.

2.2.1.2 On-Highway Commercial Travel

The FRATE3 module generates total national VMT by trucks in commercial service according to fuel used (gasoline or diesel fuel) and weight category (light, medium, light-heavy, or heavy-heavy). For purposes of on-highway emission-factor computation, as reported in Ref. 1, it is necessary only to distinguish among light- and heavy-duty VMT by fuel type. Unlike the DPTAM/POINTS synergy, FRATE3 does not separate vehicular travel into local and intercity components. Therefore, all light-duty commercial driving in effect takes place at average local speeds, due to the POINTS split (Sec. 2.2.1.1), while heavy-truck travel is apportioned as follows: for heavy-duty gasoline-powered trucks (emission class HDGT), 80% local, 20% intercity; for heavy-duty diesel-powered trucks (emission class HDDT), 30% local, 70% intercity. This division is based on speed class for MOBILE3, and the specific location of truck activity is not necessarily assumed.

Categorical national forecasts of the operation of urban and intercity transit buses (diesel) and school buses (predominantly gasoline) have been prepared independently of TEEMS. These VMT totals are added to local, intercity, and local national totals from FRATE3 prior to state-level allocation.

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*These SO_2 factors have been updated to reflect current and projected improvements in car and truck fuel efficiency relative to the efficiencies assumed in the emission factors published in App. D of Document AP-42. For example, average LDV fuel efficiency increases from 15 mi/gal in 1980 to 32 mi/gal by 2020, while average light-duty truck (LDT) fuel efficiency rises from 11 mi/gal in 1980 to 28 mi/gal in 2020, with per-mile SO_2 emission rates decreased accordingly.

‡LDGT = light-duty gasoline-powered truck, LDDT = light-duty diesel-powered truck.

In summary, the procedure discussed above produces activity by three vehicular emission categories (LDV, LDGT, LDDT), each operating at two speed levels, and by two vehicular emission categories (HDGV, HDDV) operating at a weighted speed based on travel proportions. Table 11 shows the assumed operating speed for each category used in developing MOBILE3 emission factors.

2.2.2 Off-Highway Sources

Off-highway transportation emission sources include the following:

- Rail locomotives in line-haul and switching operation,
- Air passenger operations,
- Air cargo operations,
- General aviation,

TABLE 11 Average Operating Speeds Used in Developing MOBILE3 Emissions Factors (mi/h)

	Vehicle Type				
Travel	LDV[a]	LDGT[b]	LDDT	HDGV[c,d]	HDDV[a,e]
Local	19.6	15.0	15.0	12.5	25.0
Intercity	50.0	50.0	50.0	45.0	55.0

[a]Due to extremely low penetration of diesel-powered cars in the reference-case scenario, emission factor computation for LDV was preweighted between LDGV (light-duty gasoline-powered vehicle) and LDDV (light-duty diesel-powered vehicle) using roughly a 3% diesel share of fleet.

[b]LDGT includes LDGT1 and LDGT2. MOBILE3 provides a preweighted emission factor.

[c]HDGV includes school-bus operation, while HDDV includes intercity and transit-bus VMT.

[d]Local travel = 80%, intercity travel = 20%.

[e]Local travel = 30%, intercity travel = 70%.

- Military aviation,

- Diesel barge and motorship operations,

- Marine steamship (residual- and distillate-fuel-burning) operations, and

- Natural gas pipeline compressor operation.

Conversion of TEEMS outputs to quantities compatible with AP-42 factors is discussed below for each category. For most categories, except as noted, AP-42 requires the user to supply a value for fuel consumed in operation by each of these modes. In general, the value is expressed in thousands of gallons (10^3 gal).

2.2.2.1 Rail Locomotive Transportation

Projections of fuel consumed in railroad operations are generated separately in TEEMS for switching and line-haul movements. Converted to units of 10^3 gal, these projections are readily translated to emissions through AP-42 factors if certain assumptions are made about the future mix of switching and line-haul locomotive propulsion plants. For TEEMS, a gradual shift of power plants is assumed, from 75% two-stroke/25% four-stroke engines to equal shares (50%/50%) by 2020, together with a gradual phaseout of supercharged (Rootsblow) units.

2.2.2.2 Commercial Air Transportation

The AP-42 factors for aircraft activity are based on total operations, rather than directly on fuel demand. This operating basis requires an extension of the procedures currently followed in TEEMS.

Air-passenger trip forecasts by state made by POINTS are converted to landing/takeoff (LTO) cycles through three multipliers:

1. Average seating capacity and load factor per LTO cycle (higher for states with major high-volume terminals),

2. Transit factor to account for low average boarding rates at intermediate (hub) stops,

3. Adjustments to specific state totals if a high proportion of flights is on commuter or low-capacity aircraft (states with low population densities are generally included).

Dedicated air-cargo energy consumption from FRATE3 is converted to LTO cycles by an empirically derived factor [using data from DOE's Energy Information Administration (EIA) and the U.S. Department of Transportation's (DOT's) Federal Aviation Administration (FAA)] of 26×10^6 Btu/LTO cycle. Emission factors are derived through document AP-42 from the weighted distribution of commercial air flight hours by aircraft type for 1979-83, as obtained from DOT/FAA data. States with hub airports have somewhat higher average emission factors due to the contribution of widebody aircraft.

2.2.2.3 General Aviation

Fuel demand by general aviation (aviation gasoline and jet fuel) in 1980, as obtained from data reported by Oak Ridge National Laboratory (ORNL), was calibrated to 1980 operations totals from DOT/FAA to produce an estimate of 24.15×10^6 LTO cycles. This value was extrapolated into the future on the basis of forecasts of general-aviation fuel consumption by fuel type.* No net increase is assumed in the average fuel efficiency of general-aviation aircraft currently in service. Emission factors are again weighted, based on the distribution of total hours flown by active general-aviation aircraft by type from 1979 through 1983.

2.2.2.4 Military Aviation

No change is assumed in the number of operations by domestic-based military aircraft from 1980 through 2030. Activity is frozen at 1.25×10^6 LTO cycles per year. Weighted emission factors for military-aircraft LTO cycles were derived from document AP-42 (Supplement 11, Feb. 1980), Table 3.2.1-10.

2.2.2.5 Marine Diesel Transportation

Fuel-use shares and fuel efficiency by geographic area of operation (from FRATE3) were calibrated to 1980 NAPAP emissions by source category and applied in a consistent ratio in all forecast years. As energy efficiency (Btu/ton/mi) in FRATE3 improved by area of operation, total fuel consumption responded accordingly. Fuel use on inland waterways is assumed to be 100% distillate fuel for the forecast period, while diesel fuel accounts for fueling of 70% (Btu-basis) of Great Lakes ton-mile movements (80% after 1995) and 10% of coastal ton-mile movements (20% after 1995) in FRATE3.

Overall distillate-fuel consumption is obtained by converting from British thermal units to thousands of gallons and allocating this consumption to either motorship or bunker fueling applications for the purpose of emissions forecasting. A consistent motorship-to-bunker-application ratio of 75%/25% was applied through 2030.

2.2.2.6 Marine Residual Fuel

Residual fuel for bunkering is responsible for 30% of Great Lakes (20% after 1995) and 90% of coastal (80% after 1995) marine ton-mile movements in FRATE3.

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*These forecasts are based on categorical growth rates and are independent of input-sensitive TEEMS modeling procedures; see Table 2 of Ref. 1.

Using the FRATE3 fuel efficiencies cited above, residual fuel consumption (in thousands of gallons) is directly extractable for use with the relevant AP-42 emission factors. It has been assumed that the sulfur content of residual fuel will increase from an average of 2% by weight (wt-%) to 3 wt-% by no later than 2000.

2.2.2.7 Pipeline Compressors

Natural gas pipeline compressor emissions are expressed in pounds of pollutant per million standard cubic feet (lb/10^6 scf) of gas used by the compressors. The FRATE3 module forecasts the quantity of gas consumption (in Btu) required to transport the total volume of gas demanded in TEEMS scenario years. This value is readily convertible to an emission-factor-compatible quantity by using the ratio 1,050 Btu/scf.

3 REGIONALIZATION

Most of the TEEMS activity-module output (except for that from POINTS) is in the form of national totals. However, a key objective of NAPAP is to develop sectoral emissions forecasts at the state level. It was necessary, therefore, to select a procedure for disaggregating the TEEMS national activity totals into state-by-state data in order to regionalize emissions results.

Table 12 indicates the empirical sources of data used in allocating TEEMS's national-level activity forecasts to states and the manner in which these data were converted to state-level fractional shares. State-level shares are constant through all forecast years. For future work, shifts in state-level shares may be allowed on the basis of regional results for other sectors (however, overall transportation activity does not and will not necessarily change at the same rate as other sectoral activities). Actual state-level shares, developed from the data either by direct normalization or by trending, are shown by source category in Table 13.[24-28]

Appendix B presents the stream of emission factors initially used in the reference-case model run. Additional assumptions with respect to input parameters were adopted from Refs. 29 and 30. (Some truck-related factors were subsequently revised at the recommendation of the EPA Motor Vehicle Emissions Laboratory, Ann Arbor, Michigan, to reflect changes promulgated in 1985 in the final emission standards for light and heavy trucks.) On-highway factors for VOC and SO_2 are state-specific by year; all other factors are specific only to forecast year, type of operation, or (in a few cases) both. States were grouped by similarity in isothermal/hygrometric regime for MOBILE3, which resulted in development of seven separate input streams to compute emission factors. California emission factors were developed from the EMFAC6D model used by the California Air Resources Board (CARB); R. Sunnoye of CARB provided the data necessary to generate these factors. The state groupings used were as follows:

- **Group I.** Alabama, Arkansas, Delaware, District of Columbia, Georgia, Kentucky, Louisiana (0.5), Maryland, Mississippi, Missouri, North Carolina, Oklahoma (0.5), South Carolina, Tennessee, and Virginia.

- **Group II.** Connecticut, Illinois, Indiana, Iowa, Kansas, Massachusetts, Nebraska, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Washington, and West Virginia.

- **Group III.** Maine, Michigan, Minnesota, Montana, New Hampshire, North Dakota, South Dakota, Vermont, and Wisconsin.

- **Group IV.** Colorado, Idaho, Wyoming, Nevada, and Utah.

- **Group V.** Arizona, New Mexico, Oklahoma (0.5), and Texas (0.5).

- **Group VI.** Florida, Louisiana (0.5), and Texas (0.5).

- **Group VII.** California.

TABLE 12 Empirical Data Sources of State-Level Activity Allocation by Emission Category: Transportation

Source of Data	Description of Data	Emission Source
Federal Highway Administration (DOT/FHWA)	Trended state shares of highway VMT, 1978-83	LDVs (automobiles) LDGTs HDGTs School buses
	Trended state shares of diesel fuel sales for highway use, 1978-83	LDDTs HDDTs Urban transit buses Intercity buses
Energy Information Administration (DOE/EIA)	Average state shares of diesel fuel sold to railroads, 1982-83	Line-haul locomotive Switching locomotive
	Average state shares of distillate fuel sold for vessel bunkering, 1982-83	Diesel motorship and barge) operation
	Average state shares of residual fuel sold for vessel bunkering, 1980-81	Steamship operation (including diesel fuel burned as bunker fuel)
	Average state shares of natural gas consumption, 1980-81	Pipeline compressor operation
Federal Aviation Administration (DOT/FAA)	Average state shares of revenue aircraft departures, 1981-83	All-cargo commercial-aircraft LTO cycles
	Average hours of flight time by state-registered private aircraft, 1981-83	General-aviation LTO cycles
TEEMS (direct)	POINTS state-level trip vector results	Intercity personal travel in cars and light trucks Intercity commercial-air-passenger LTO cycles
1980 NAPAP	NAPAP/NEDS[a] state share	Military-aviation LTO cycles

[a]NEDS = National Emission Data Survey.

TABLE 13 State Shares of Transportation Activity by TEEMS Classification

State	Highway: Passenger Travel	Highway: Commercial Diesel	Railroad	Aircraft: Cargo	Aircraft: General Aviation	Aircraft: Military Aviation	Marine: Diesel Fuel	Marine: Residual Fuel	Pipeline Compressors
Alabama	0.0185	0.0205	0.0346	0.0090	0.0125	0.0325	0.0376	0.0158	0.0140
Alaska	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Arizona	0.0120	0.0135	0.0132	0.0210	0.0230	0.0177	0.0000	0.0000	0.0100
Arkansas	0.0100	0.0165	0.0295	0.0030	0.0140	0.0144	0.0044	0.0000	0.0135
California	0.1110	0.0810	0.0767	0.1000	0.1300	0.0775	0.0563	0.3510	0.1000
Colorado	0.0150	0.0120	0.0202	0.0410	0.0280	0.0122	0.0000	0.0000	0.0110
Connecticut	0.0125	0.0082	0.0001	0.0060	0.0100	0.0079	0.0005	0.0001	0.0040
Delaware	0.0030	0.0026	0.0003	0.0000	0.0025	0.0135	0.0002	0.0009	0.0015
Dist. of Col.[a]	0.0020	0.0013	0.0008	0.0023	0.0010	0.0013	0.0000	0.0000	0.0014
Florida	0.0500	0.0405	0.0179	0.0750	0.0775	0.0550	0.0897	0.0386	0.0200
Georgia	0.0300	0.0370	0.0228	0.0570	0.0270	0.0389	0.0176	0.0151	0.0165
Hawaii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Idaho	0.0050	0.0045	0.0061	0.0060	0.0070	0.0030	0.0000	0.0000	0.0020
Illinois	0.0410	0.0365	0.0510	0.0570	0.0400	0.0330	0.0029	0.0000	0.0550
Indiana	0.0250	0.0390	0.0368	0.0125	0.0150	0.0094	0.0031	0.0002	0.0255
Iowa	0.0120	0.0190	0.0235	0.0070	0.0150	0.0102	0.0011	0.0000	0.0125
Kansas	0.0110	0.0155	0.0452	0.0080	0.0150	0.0162	0.0000	0.0000	0.0235
Kentucky	0.0165	0.0195	0.0286	0.0065	0.0125	0.0108	0.0828	0.0000	0.0103
Louisiana	0.0165	0.0215	0.0283	0.0160	0.0330	0.0216	0.1431	0.1262	0.0930
Maine	0.0050	0.0045	0.0014	0.0015	0.0040	0.0137	0.0027	0.0041	0.0001
Maryland	0.0185	0.0140	0.0052	0.0080	0.0120	0.0224	0.0151	0.0187	0.0090
Massachusetts	0.0230	0.0140	0.0026	0.0190	0.0125	0.0112	0.0054	0.0036	0.0095
Michigan	0.0380	0.0250	0.0131	0.0275	0.0300	0.0143	0.0016	0.0002	0.0400
Minnesota	0.0185	0.0184	0.0187	0.0210	0.0220	0.0154	0.0087	0.0003	0.0135
Mississippi	0.0110	0.0156	0.0095	0.0045	0.0105	0.0182	0.0198	0.0165	0.0125
Missouri	0.0225	0.0255	0.0277	0.0350	0.0200	0.0272	0.0209	0.0000	0.0140
Montana	0.0045	0.0070	0.0161	0.0074	0.0090	0.0112	0.0000	0.0000	0.0025
Nebraska	0.0070	0.0115	0.0105	0.0066	0.0075	0.0058	0.0001	0.0000	0.0065

TABLE 13 (Cont'd

State	Highway: Passenger Travel	Highway: Commercial Diesel	Railroad	Aircraft: Cargo	Aircraft: General Aviation	Aircraft: Military Aviation	Marine: Diesel Fuel	Marine: Residual Fuel	Pipeline Compressors
Nevada	0.0040	0.0055	0.0078	0.0210	0.0100	0.0123	0.0000	0.0000	0.0045
New Hampshire	0.0045	0.0021	0.0001	0.0001	0.0060	0.0027	0.0003	0.0002	0.0005
New Jersey	0.0320	0.0260	0.0054	0.0144	0.0235	0.0276	0.0528	0.0793	0.0200
New Mexico	0.0075	0.0095	0.0225	0.0080	0.0090	0.0230	0.0000	0.0000	0.0100
New York	0.0510	0.0260	0.0100	0.0620	0.0290	0.0412	0.0190	0.0211	0.0400
North Carolina	0.0275	0.0290	0.0105	0.0260	0.0225	0.0364	0.0030	0.0014	0.0080
North Dakota	0.0035	0.0057	0.0095	0.0040	0.0090	0.0168	0.0000	0.0000	0.0015
Ohio	0.0445	0.0490	0.0547	0.0330	0.0350	0.0257	0.0010	0.0002	0.0450
Oklahoma	0.0180	0.0235	0.0148	0.0110	0.0200	0.0226	0.0000	0.0000	0.0350
Oregon	0.0125	0.0170	0.0281	0.0095	0.0200	0.0112	0.0295	0.0364	0.0040
Pennsylvania	0.0440	0.0455	0.0163	0.0340	0.0275	0.0330	0.0094	0.0110	0.0400
Rhode Island	0.0035	0.0019	0.0001	0.0015	0.0015	0.0033	0.0009	0.0001	0.0015
South Carolina	0.0150	0.0168	0.0047	0.0055	0.0090	0.0298	0.0028	0.0052	0.0073
South Dakota	0.0040	0.0055	0.0023	0.0030	0.0050	0.0026	0.0000	0.0000	0.0012
Tennessee	0.0220	0.0290	0.0300	0.0215	0.0155	0.0117	0.0423	0.0000	0.0116
Texas	0.0800	0.0970	0.1379	0.0985	0.0950	0.0721	0.2528	0.2069	0.2013
Utah	0.0070	0.0075	0.0133	0.0125	0.0060	0.0109	0.0000	0.0000	0.0050
Vermont	0.0025	0.0020	0.0001	0.0010	0.0015	0.0079	0.0002	0.0000	0.0002
Virginia	0.0255	0.0255	0.0230	0.0120	0.0100	0.0150	0.0178	0.0178	0.0075
Washington	0.0210	0.0165	0.0127	0.0215	0.0250	0.0363	0.0478	0.0289	0.0065
West Virginia	0.0070	0.0075	0.0130	0.0020	0.0045	0.0177	0.0048	0.0000	0.0075
Wisconsin	0.0210	0.0210	0.0104	0.0165	0.0190	0.0190	0.0027	0.0002	0.0170
Wyoming	0.0035	0.0069	0.0324	0.0030	0.0060	0.0067	0.0000	0.0000	0.0036

[a]U.S. Federal District of Columbia.

Source: Refs. 24-28.

4 RESULTS

The TEEMS activity module was executed to make projections at five 10-year intervals in the period 1990-2030; the results were then interpolated for mid-decade points. These results show a consistent increase in transportation activity at a rapid rate up to the year 2000, followed by increases at a slower rate to 2030.

4.1 ON-HIGHWAY MODES

The Disaggregate Vehicle Stock Allocation Module (DVSAM) projected a greater penetration by the four-passenger Otto vehicle (small Otto) over the current fleet. Table 14 shows projected shares for the various household vehicles. The diesel share of household vehicles is not projected to be significant; it rises from 2.07% in 1990 to 2.76% in 2030, with the largest increase projected between 1990 and 2000. The six-passenger Otto vehicle's share remains nearly constant between 1990 and 2000 and then shows a steady decline.

Vehicle-miles of travel by personal vehicle increase at a high rate during the period 1985-2000; after this period, the rate of increase diminishes. Table 15 lists VMT by personal automobiles and light trucks. Gasoline automobile VMT increase at an annual rate of 1.3% between 1985 and 2000 and then at an annual rate of 0.7%. Diesel automobile VMT increase initially at a much higher rate, 7.6%. This high rate results mainly from the increase in diesel automobiles' market share from a small baseline (from 2.03 to 2.60% of fleet). The rate of increase in diesel VMT is 0.8% annually beyond the year 2000. The diesel share of the total automobile VMT rises from 1.2% in 1985 to 2.8% in 2000 and then shows only a marginal additional increase of share to 2.9% up to the year 2030.

Compared with other, similar forecasts, these automobile VMT forecasts are reasonable. Comparable forecasts by DRI, EIA, and Energy and Environmental Analysis, Inc. (EEA), have been published recently.[31-33] Each of these forecasts uses different economic, energy, demographic, and technological assumptions. Different modeling approaches are also used. Figure 3 shows automobile VMT projections contrasted against fuel cost per mile for TEEMS and three other forecasts. Fuel cost per mile in Fig. 3 reflects the effect of fuel price and technological assumptions. The TEEMS assumes higher fuel cost per mile, showing greater differences beyond 2000; it projects the lowest VMT (although not very much different from that projected by DRI). The TEEMS uses NEPP-5 fuel prices and a set of technological assumptions that differ from those of other forecasts. Vehicle technology development, production, and marketing are difficult to model fully in vehicle-activity and emissions-forecasting procedures. Although it is normally agreed that a relationship exists among these variables, income, and fuel prices, the exact nature of this relationship and the estimation of variables causing shifts in consumer preference are not modeled but are empirically, exogenously determined. For comparison of TEEMS projections with those of other forecasts at various points in time, see Refs. 7, 13, and 34.

TABLE 14 Projected Household Vehicle Holdings — Reference Case

Vehicle	1990 Share (%)	1990 Share, Excluding Minivans (%)	2000 Share (%)	2000 Share, Excluding Minivans (%)	2010 Share (%)	2010 Share, Excluding Minivans (%)	2020 Share (%)	2020 Share, Excluding Minivans (%)	2030 Share (%)	2030 Share, Excluding Minivans (%)
Mini Otto	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Small Otto	31.7	32.3	33.4	34.2	35.8	36.6	38.3	39.0	40.2	40.9
Medium Otto	29.5	30.1	26.6	27.2	28.3	29.0	28.1	28.6	27.6	28.1
Large Otto	34.4	35.0	34.6	35.4	30.6	31.2	28.5	29.1	27.1	27.6
Composite diesel	2.0	2.1	2.6	2.7	2.6	2.6	2.6	2.7	2.7	2.8
Otto minivan	1.9	-	2.2	-	2.0	-	1.7	-	1.6	-
Diesel minivan	-	-	0.1	-	0.2	-	0.2	-	0.2	-

TABLE 15 Projected Vehicle-Miles by On-Highway Modes — Reference Case

Transportation Mode and Submode	Vehicle-Miles of Travel by Year (10^9 mi)								Annual Change (%)	
	1985	1990	1995	2000	2005	2010	2020	2030	1985-2000	2000-2030
Automobiles										
Gasoline	1,230.3	1,361.2	1,428.6	1,499.3	1,571.9	1,648.0	1,760.4	1,850.7	1.3	0.7
Diesel	14.5	30.1	36.2	43.6	45.5	47.5	51.6	55.4	7.6	0.8
Light trucks										
Gasoline, personal[a]	233.4	287.3	288.9	290.6	289.3	288.1	299.0	306.7	1.5	0.2
Diesel, personal[a]	5.9	6.9	9.3	12.5	17.4	24.1	22.7	23.3	5.1	2.1
Gasoline, commercial	107.5	118.4	124.9	131.8	137.3	143.0	162.7	185.2	1.4	1.1
Diesel, commercial	2.9	8.6	14.1	23.3	31.4	42.4	44.1	50.2	14.9	2.6
Heavy trucks[b]										
Gasoline	36.6	32.8	28.2	24.3	22.7	21.2	21.4	23.4	-2.7	-0.1
Diesel	86.9	107.7	125.6	146.5	163.7	183.0	199.7	219.0	3.5	1.3

[a]Includes minivans.

[b]Includes buses.

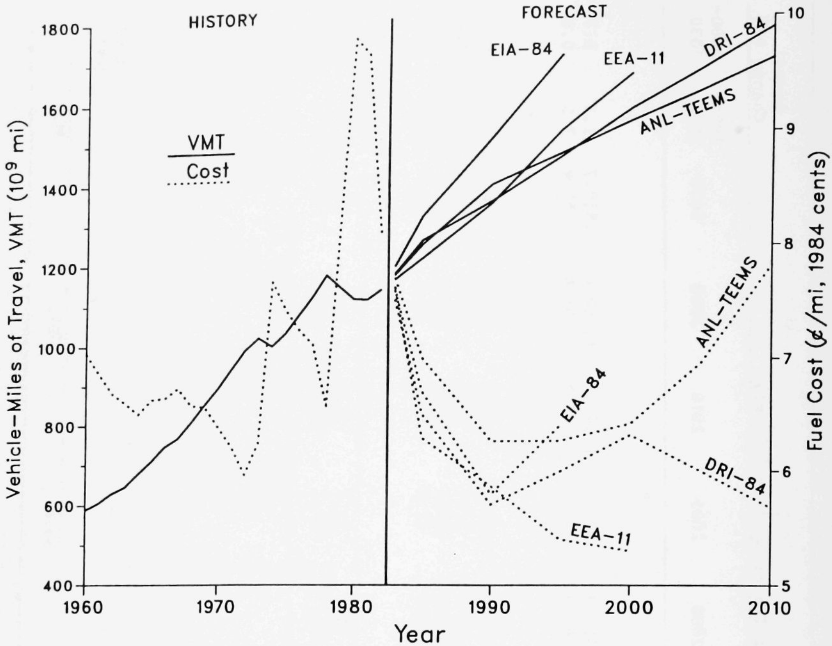

FIGURE 3 Automobile Vehicle-Miles and Fuel Cost per Mile for Four Forecasts

Gasoline personal light-truck VMT in Table 15 rise at an annual rate of 1.5% between 1985 and 2000, higher than the comparable automobile VMT rate. The annual rate of increase in gasoline truck VMT is only 0.2% beyond the year 2000. This slow rate of increase is caused chiefly by the reduction in the number of households most likely to own light trucks. Diesel truck VMT increase up to 2010, decline by 2020, and then rebound slightly by 2030. Light trucks' share of the total personal VMT increases from 16.1% in 1985 to 16.4% in 2000 and then declines to 14.8% in 2030. Demographic changes, mainly an aging population and higher household income, appear to be responsible for this pattern.

Table 15 also lists commercial trucks' VMT. The VMT for commercial trucks are projected to increase for all vehicle types except heavy-duty gasoline trucks. The VMT for heavy-duty trucks in the table include VMT for buses, which were estimated from an earlier ANL study.[12] Increased dieselization of heavy-duty trucks leads to a loss of 36.1% in HDGT VMT; by contrast, HDDT VMT increase by 152% during the analysis period. The annual rate of increase is 3.5% during 1985-2000 and 1.3% thereafter. The VMT for light-duty commercial trucks increase by 113%, with 40% of the increase taking place between 1985 and 2000.

4.2 OFF-HIGHWAY MODES

The TEEMS activity module projects fuel consumption and related information for the off-highway modes. Table 16 lists projections of fuel consumption by rail, marine, and natural gas pipeline modes. The table also lists LTO cycles for the air mode. Rail fuel consumption rises at an annual rate of 3.3% up to the year 2000 and then at 1.6% annually. The overall increase in the railroads' energy use is projected to be 164% during the analysis period. A high rate of growth in coal production and expected operational improvements enhancing its attractiveness to shippers are the main factors behind increased use of rail transportation.

Marine diesel-fuel consumption rises at an annual rate of 1.4% between 1985 and 2000 and then at a slower rate of 0.6%. The use of residual fuel rises at a steady rate of 0.6-0.7% annually through the analysis period. The growth in diesel-fuel consumption represents an increase in motorship mode share for inland waterways and Great Lakes shipping and also an overall increase in economic activity. The growth in residual-fuel consumption represents growth in coastal activity.

Aircraft LTO cycles for general aviation increase by 175%; other air sectors do not show such high growth. This general-aviation increase is in response to the higher rate of economic expansion, which has historically fostered more business aviation. The lack of growth for the military sector through the analysis period and for the intercity passenger sector for the years 2005-2030 (Table 16) reflects the unavailability of data. General-aviation LTO cycles are computed on the basis of ANL's energy-use projection[6] and 1980 FAA data.

4.3 EMISSIONS

Emissions of VOC, NO_x, and SO_2 were computed using the EPA's MOBILE3 model and AP-42 factors. Table 17 lists the total quantities (tons) of pollutants emitted by transportation sources. The rate of change in emission levels for these three pollutants is also shown in Fig. 4. Emissions of VOCs decline through the year 2000 and then show a modest rise, from 74% of the 1985 level in 2000 to 89% of the 1985 level in 2030. Emissions of NO_x also decline, but the trend reverses after 1995 (from a low point of 95% of the 1985 level); the 1985 level is passed after 2000, and 133% of the 1985 level is reached by 2030. Emissions of SO_2 increase with the use of residual fuel (because of its expected higher sulfur content) after 1995. The rate of growth in SO_2 emissions is steep during the period 2000-2010, when the sulfur content of residual fuel is expected to rise.

The reduction in VOC emissions is achieved through current and programmed regulations to the year 2000. The projected increase in VOC emissions beyond 2000 results from an increase in transportation activity (and no additional regulations). The reduction in NO_x emissions results from existing regulations on highway modes, but -- because of the high rate of increase in off-highway activity (and in less stringently regulated heavy-duty diesel trucks) -- the level of reduction is small, and the rate of increase beyond the year 2000 is faster. The continuous rise in SO_2 emissions results from an increase in unregulated off-highway activity and an increase in sulfur content of residual fuel; this trend could be exacerbated if the sulfur content of diesel fuel is also permitted to rise.

TABLE 16 Projected Transportation Activity/Fuel Consumption by Off-Highway Modes — Reference Case

Transportation Mode and Submode	1985	1990	1995	2000	2005	2010	2020	2030	Annual Change (%) 1985–2000	Annual Change (%) 2000–2030
Rail diesel-fuel consumption (10^9 gal)										
Line haul	4.13	4.95	5.78	6.76	7.81	9.03	9.83	10.98	3.3	1.6
Switching	0.52	0.61	0.71	0.83	0.96	1.10	1.18	1.32	3.2	1.5
Total	4.65	5.56	6.50	7.59	8.77	10.13	11.01	12.30	3.3	1.6
Marine fuel consumption (10^9 gal)										
Diesel, direct	0.93	1.03	1.09	1.14	1.21	1.27	1.29	1.36	1.4	0.6
Diesel, bunker	0.31	0.34	0.36	0.38	0.40	0.42	0.43	0.45	1.4	0.6
Residual	1.30	1.26	12.34	1.42	1.51	1.60	1.65	1.75	0.6	0.7
Aircraft LTO cycles (10^6)										
Cargo	0.13	0.13	0.14	0.14	0.16	0.18	0.17	0.20	0.7	1.1
Passenger[a]	6.39	6.46	7.04	7.67	7.67	7.67	7.67	7.67	1.2	–
General[b]	24.15	32.34	36.08	40.26	45.69	51.85	66.50	66.50	3.5	1.7
Military[c]	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	–	–
Pipeline natural gas consumed (10^9 ft^3)	639.86	633.38	620.21	607.33	574.12	542.74	501.49	492.26	-0.3	-0.7

[a]Kept constant beyond 2000, because city-level data were not available.

[b]Based on ANL projection of general-aviation energy use. FAA data from 1980 were indexed to energy usage.

[c]Based on FAA data. Kept constant for the analysis period.

TABLE 17 Transportation-Source Emissions by Pollutant — Reference Case[a]

	Pollutant Emissions by Year (10^6 tons)								Annual Change (%)	
Pollutant	1985	1990	1995	2000	2005	2010	2020	2030	1985–2000	2000–2030
VOC	6.89	6.08	5.51	5.07	5.13	5.37	5.76	6.14	-2.02	0.64
NO_x	7.85	7.61	7.42	7.79	8.31	8.98	9.64	10.42	-0.05	0.97
SO_2	0.79	0.80	0.86	0.93	1.12	1.23	1.27	1.38	1.09	1.32

[a]Preliminary projections using test data based on NEPP-5.

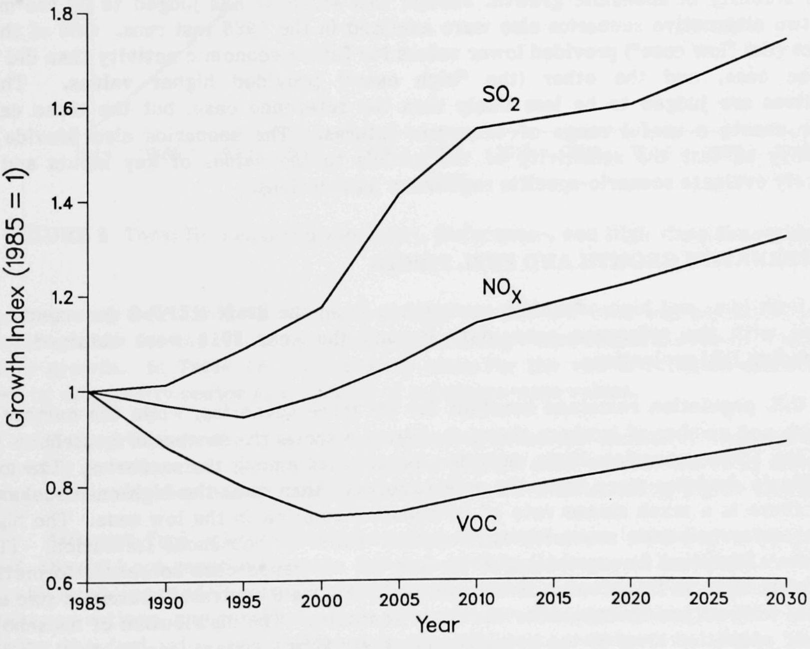

FIGURE 4 Growth Index of Pollutants — Reference Case [Preliminary projections using test data based on NEPP-5]

5 TEEMS SENSITIVITY ANALYSIS: ALTERNATIVE ECONOMIC AND FUEL-PRICE SCENARIOS

This section describes a preliminary sensitivity analysis and its results. Conducting sensitivity analyses to test the ability of TEEMS to respond to various alternative scenarios is included among the integration tasks for the NAPAP test and model runs.

5.1 ALTERNATIVE ECONOMIC SCENARIOS

The NAPAP reference-case scenario represents a mid-range economic-growth and fuel-price scenario. This scenario reflects a future in which economic growth continues at a rate expected to occur under "most likely" conditions. Fuel supply and demand are assumed to follow a similar path, resulting in fuel prices that provide relative stability in economic growth. Though this scenario was judged to be the most likely, two alternative scenarios also were assessed in the 1985 test runs. One of these scenarios (the "low case") provided lower values for future economic activity than did the reference case, and the other (the "high case") provided higher values. These alternatives are judged to be less likely than the reference case, but the three cases together create a useful range of economic futures. The scenarios also provide an opportunity to test the sensitivity of the models to the values of key inputs and to objectively evaluate scenario-specific regulatory assumptions.

5.2 ALTERNATIVE GROWTH AND FUEL PRICES

Both low- and high-case data were taken from the draft NEPP-5 document. As was done with the reference case, data beyond the year 2010 were obtained from corresponding DRI projections.

U.S. population remained constant for all three scenarios, while the number of households and number of workers changed. Figure 5 shows the number of households for each of the three scenarios; little variation can be seen among the scenarios. The low-case scenario deviates more from the reference case than does the high-case scenario, because there is a much slower rate of household formation in the low case. The high-case and reference-case scenarios have similar rates of household formation. (The population is identical among the scenarios and the reference-case household formation rate is fairly high, so this trend is to be expected.) Figure 6 contrasts household size and number of workers per household for the three scenarios. The distribution of households by age and education level of the household head was kept constant (see Table 3), as was the split between urban and rural location. The fraction of households in low-, middle-, and upper-income groups changed as total personal income changed in the DRI macroeconomic projections. Figure 7 shows the resulting differences in distribution of households by income category.

Growth in freight TMT was computed using NEPP-5 energy-sector projections and DRI indexes of industrial production; the method used is the same as that for the

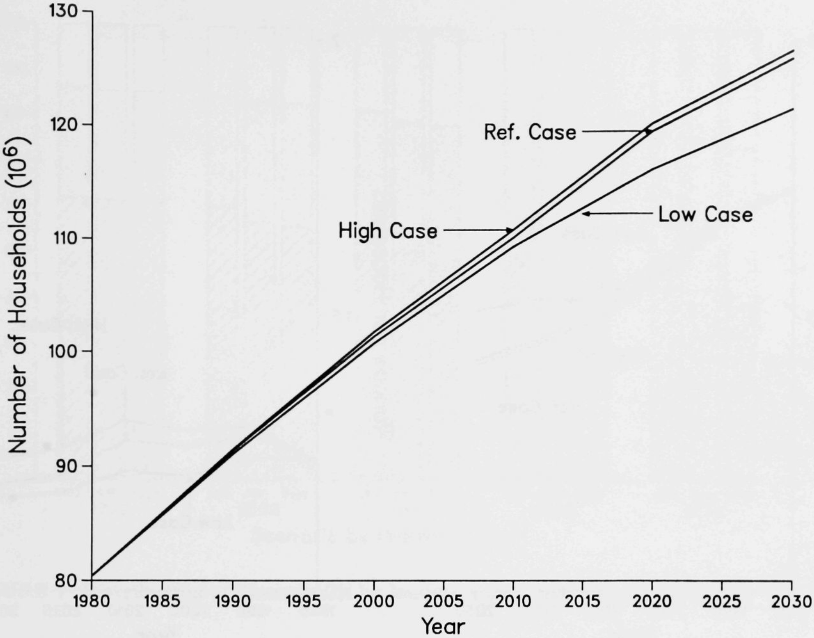

FIGURE 5 Total Households under Low-, Reference-, and High-Case Scenarios

reference case (see Table 7). Growth in TMT for the low case was consistently lower than the growth for the reference case, while the high-case scenario showed consistently greater growth. In Table 18, TMT growth rates for the two alternative scenarios are shown by commodity sector as multiples of reference-case values.

Fuel prices under the two alternative scenarios showed trends similar to commodity growth rates. Thus, fuel prices for the low case were consistently lower than those for the reference case, while high-case prices were consistently higher (see Fig. 8).

Although fuel prices varied from the reference case, providing a range to be tested, they did not reach extremes. Because of this, the menu of household vehicles (in the vehicle-choice model) was unchanged for the three scenarios. Vehicle curb weights, horsepower ratings, and purchase prices were also constant (see Table 4). The effect of changing the fuel price was reflected in the vehicle operating cost. Table 19 shows vehicle operating costs for the seven household vehicles included in the vehicle-choice model's menu. These operating costs include costs of vehicle maintenance. Similar changes were made in the light-truck operating cost, where the gasoline and diesel split was unchanged for the three scenarios. Diesel penetration levels and fuel economy for commercial trucks remained constant, as did energy intensities for rail, marine, and air travel.

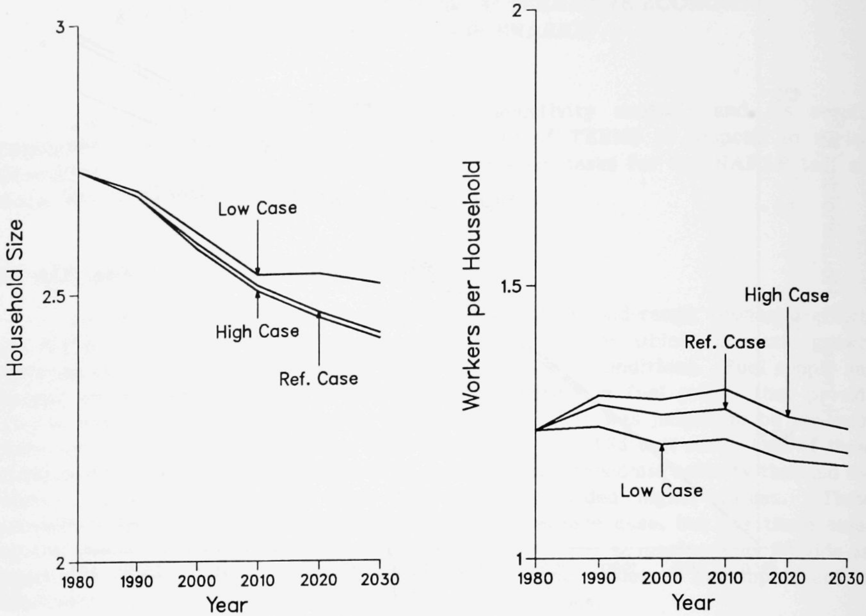

FIGURE 6 Household Size and Workers per Household under Three Scenarios

5.3 RESULTS FOR ALTERNATIVE SCENARIOS

The TEEMS activity and emissions modules were executed to make projections at 10-year intervals for both alternative scenarios. The results show a varying degree of change in transportation activity. The amount of change was primarily dependent upon the economic driver data (e.g., demographics and industrial growth). Section 5.3.1 compares results for some important components.

5.3.1 On-Highway Modes

Household vehicle holdings changed in response to changes in income, household size, and vehicle operating cost. Table 20 lists household vehicle holdings for 1990-2030. Under the low-case scenario, small (four-passenger) Otto-cycle vehicles have a declining share, while large (six-passenger) Otto-cycle vehicles show a gain. The high-case scenario has opposite effects on the shares of small and large Otto-cycle vehicles.

Vehicle-miles of travel for the on-highway modes are listed in Table 21. Compared with VMT for the reference-case scenario, VMT by all highway modes are consistently lower for the low-case scenario. For the high-case scenario, such

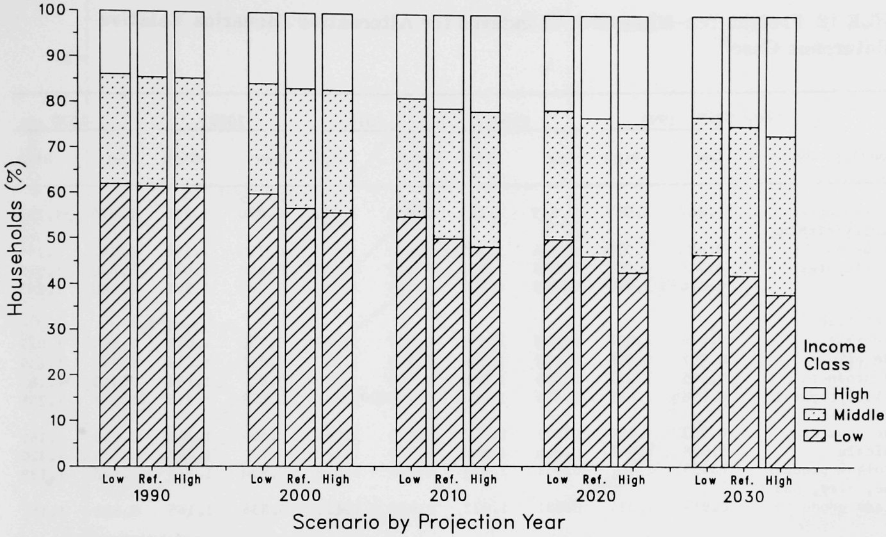

FIGURE 7 Distribution of Households by Income Class under Three Scenarios

consistency is not observed. High fuel prices keep personal truck VMT from rising, while automobile VMT continue to rise as households shift toward fuel-efficient automobiles. Also, as household income increases, the truck ownership rate drops. A similar effect is observed in heavy-duty-truck VMT, because freight-mode choice is affected by higher fuel prices.

5.3.2 Off-Highway Modes

Projection of off-highway activity relied on the availability of driver input data. In the case of air movement, projections were made for cargo-aircraft LTO cycles only, because alternative-scenario data for general and military aviation and alternative SMSA-level demographic- and economic-forecasting data for passenger-aircraft operation were not available. In all of these cases, reference-case results were substituted, so that no changes are assumed in these activities among scenarios. The lack of projections for general aviation, military aviation, and intercity tracp, does not greatly affect the results, because the overall contribution of these activities to acid-rain precursor emissions is small. The effect within the sensitivity analysis is not even observable, because reference-case results are included. Table 22 lists relative activity/fuel-consumption levels for the rail, marine, air, and natural gas pipeline modes, indexed to the corresponding reference-case results.

TABLE 18 Freight Ton-Miles Growth Indexes for Alternative Scenarios Relative to Reference Case[a]

Commodity Sector	1990 Low	1990 High	2000 Low	2000 High	2010 Low	2010 High	2020 Low	2020 High	2030 Low	2030 High
Farm products	0.967	1.037	0.913	1.140	0.881	1.192	0.876	1.266	0.876	1.269
Forestry/fishing products	0.882	1.039	0.834	1.085	0.781	1.111	0.759	1.136	0.747	1.144
Metallic ores	0.916	1.007	0.889	1.031	0.857	1.049	0.850	1.071	0.890	1.079
Coal	0.816	1.054	0.729	1.207	0.743	1.335	0.780	1.522	0.780	1.562
Nonmetallic minerals	0.916	1.007	0.889	1.031	0.857	1.049	0.850	1.071	0.890	1.079
Crude oil	0.957	1.006	0.952	1.036	0.945	1.077	0.951	1.113	0.945	1.139
Food products	0.985	1.017	0.936	1.048	0.905	1.092	0.857	1.151	0.813	1.181
Textiles/apparel	0.898	1.025	0.824	1.085	0.749	1.142	0.673	1.215	0.607	1.251
Paper products	0.963	1.025	0.921	1.057	0.896	1.096	0.864	1.143	0.836	1.161
Chemicals	0.920	1.044	0.865	1.103	0.815	1.188	0.771	1.287	0.736	1.320
Petroleum products	0.958	1.007	0.951	1.035	0.945	1.076	0.950	1.113	0.945	1.139
Stone, clay, and glass products	0.914	1.034	0.881	1.072	0.853	1.111	0.834	1.145	0.826	1.151
Primary metal products	0.833	1.058	0.761	1.107	0.698	1.157	0.671	1.174	0.663	1.173
Fabricated metal products	0.849	1.040	0.813	1.101	0.797	1.153	0.787	1.192	0.790	1.192
Nonelectric machinery	0.811	1.083	0.767	1.109	0.745	1.168	0.773	1.178	0.827	1.156
Electric machinery	0.882	1.059	0.831	1.094	0.828	1.138	0.839	1.151	0.870	1.141
Transportation equipment	0.852	1.053	0.828	1.101	0.803	1.137	0.816	1.144	0.851	1.131
Miscellaneous manufactures	0.892	1.047	0.842	1.108	0.796	1.170	0.755	1.225	0.735	1.257
Retail trade	0.932	1.029	0.883	1.076	0.841	1.125	0.802	1.182	0.768	1.202
Utilities	0.977	1.014	0.927	1.042	0.873	1.068	0.814	1.101	0.765	1.125
Services	0.977	1.011	0.940	1.052	0.920	1.094	0.879	1.146	0.849	1.163
Construction	0.936	1.014	0.923	1.025	0.899	1.029	0.877	1.044	0.858	1.041
Natural gas	0.944	1.010	0.942	1.049	0.941	1.068	0.944	1.109	0.869	1.063

[a]Numbers represent ratios of alternative-scenario TMT growth indexes to the reference-case value in Table 7.

5.3.3 Emissions

Projected changes in acid-rain precursor emissions are depicted in Fig. 9. In the figure, indexes are computed relative to 1985 reference-case emissions. The projected emissions follow trends similar to those discussed in Sec. 4.3. Emissions of VOCs decline through the year 2000 for both alternative scenarios and then rise; these emissions deviate by varying amounts from the corresponding reference-case emissions, with high-case emissions on the high side and low-case emissions on the low side. Emissions of NO_x drop through 1995 (as was observed for the reference case) and then rise. These NO_x

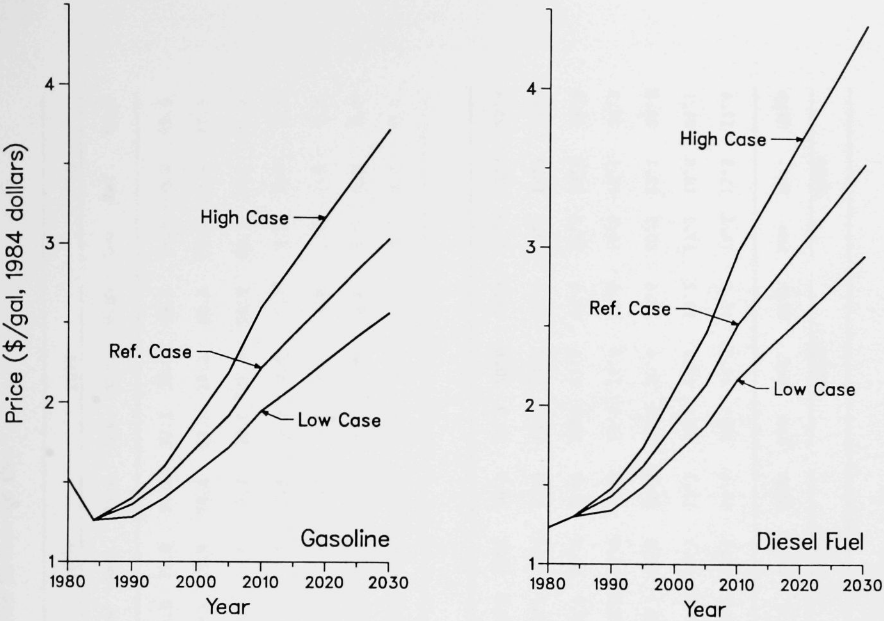

FIGURE 8 Gasoline and Diesel Prices under Three Scenarios

emissions vary by different amounts from the reference-case emissions, reaching levels of 119% and 146% of the 1985 reference-case emissions by 2030 for the low-case and high-case scenarios, respectively. Emissions of SO_2 follow similar trends, rising with the expected increase in the sulfur content of residual fuel after about 2000. The year-2030 indexes for the three scenarios are 1.53, 1.75, and 2.01 for the low-case, reference-case, and high-case scenarios, respectively.

Variations in VOC emissions among the scenarios are smaller than those for NO_x and SO_2, largely because of different growth projections for key demographic and economic sectors. The population remains the same, so personal transportation demand changes only as a result of changes in households, number of workers, and income. These changes and changes in fuel prices are countered somewhat by shifts in the household fleet, the net effect being smaller variations in travel by gasoline-powered vehicles (these constitute over 97% of the total household vehicles). Freight transportation demand, which shows substantial change resulting from changes in economic activity, is met by large increases in diesel- and residual-fuel-powered vehicles, which in turn contribute heavily to the growth in NO_x and SO_2 emissions.

TABLE 19 Vehicle Operating Costs under Three Scenarios (¢/mi)[a]

Vehicle	1990 Low	1990 Ref.	1990 High	2000 Low	2000 Ref.	2000 High	2010 Low	2010 Ref.	2010 High	2020 Low	2020 Ref.	2020 High	2030 Low	2030 Ref.	2030 High
Small Otto	11.6	11.9	12.0	11.7	12.2	12.8	12.7	13.5	14.6	13.3	14.3	15.8	14.1	15.5	17.4
Medium Otto	13.8	14.2	14.4	14.0	14.6	15.2	15.3	16.3	17.7	16.1	17.3	19.2	17.2	18.8	21.1
Large Otto	16.3	16.7	16.9	16.3	17.1	17.9	18.1	19.2	20.8	18.9	20.4	22.6	20.2	22.1	24.8
Diesel automobile	13.7	14.0	14.1	13.8	14.4	15.1	15.0	15.9	17.2	15.6	16.8	18.5	16.6	18.1	20.2
Otto minivan	15.8	16.2	16.4	16.9	17.7	18.7	18.7	20.0	21.9	19.8	21.6	24.1	21.3	23.5	26.8
Mini Otto	10.7	11.0	11.1	10.7	11.1	11.6	11.7	12.4	13.4	12.2	13.2	14.5	13.0	14.2	15.9
Diesel minivan	-	-	-	16.1	16.9	17.8	17.9	19.2	20.9	18.9	20.6	22.9	20.3	22.4	25.4

[a]1984 cents.

TABLE 20 Projected Household Vehicle Holdings under Three Scenarios (%)

Vehicle	1990			2000			2010			2020			2030		
	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High
Small Otto	31.3	31.7	31.9	32.8	33.4	34.2	35.0	35.8	37.2	37.1	38.3	40.1	38.9	40.2	42.5
Medium Otto	29.4	29.5	29.5	26.3	26.6	26.7	28.1	28.3	28.4	27.8	28.1	28.0	27.3	27.6	27.5
Large Otto	34.9	34.4	34.2	35.5	34.6	33.8	31.7	30.6	29.2	30.0	28.5	26.9	28.7	27.1	25.2
Diesel automobile	2.0	2.0	2.0	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7
Otto minivan	1.9	1.9	1.9	2.2	2.2	2.1	1.9	2.0	1.8	1.8	1.7	1.5	1.6	1.6	1.3
Mini Otto	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.7
Diesel minivan	-	-	-	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1

TABLE 21 Vehicle-Miles by On-Highway Modes under Three Scenarios (10^9 mi)

Transportation Mode and Submode	1990			2000			2010			2020			2030		
	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High	Low	Ref.	High
Automobiles															
Gasoline	1340.2	1361.2	1369.6	1460.6	1499.3	1519.2	1598.2	1648.0	1676.0	1701.2	1760.4	1804.7	1780.3	1850.7	1898.7
Diesel	29.6	30.1	30.3	42.9	43.6	43.9	46.7	47.5	48.6	49.7	51.6	53.4	52.8	55.4	57.1
Light trucks, personal[a]															
Gasoline	284.2	287.3	288.8	284.7	290.6	289.4	283.2	288.1	287.8	292.6	299.0	301.1	300.5	306.7	308.3
Diesel	6.8	6.9	7.0	12.3	12.5	12.6	23.8	24.1	24.3	22.3	22.7	23.1	22.9	23.3	23.6
Light trucks, commercial															
Gasoline	112.7	118.4	120.9	120.9	131.8	140.5	128.2	143.0	156.2	143.6	162.7	182.5	160.4	185.2	209.0
Diesel	8.2	8.6	8.7	21.3	23.3	24.8	38.0	42.4	46.4	38.9	44.1	49.5	43.5	50.2	56.7
Heavy trucks[b]															
Gasoline	31.4	32.8	31.0	22.6	24.3	23.7	19.3	21.2	21.2	19.1	21.4	22.3	20.6	23.4	25.1
Diesel	100.8	107.7	105.9	132.4	146.5	149.8	162.1	183.0	191.2	176.4	199.7	211.8	191.3	219.0	235.4

[a]Includes minivans.

[b]Includes buses.

TABLE 22 Off-Highway Transportation Modes Activity/Fuel Consumption Indexes for Alternative Scenarios Relative to Reference Case

Consumption by Mode	1990		2000		2010		2020		2030	
	Low	High	Low	High	Low	High	Low	High	Low	High
Rail diesel consumption	0.896	1.036	0.841	1.110	0.828	1.170	0.848	1.232	0.844	1.253
Marine fuel consumption	0.938	1.016	0.907	1.068	0.889	1.120	0.896	1.173	0.891	1.200
Air cargo LTO cycles	0.921	1.044	0.873	1.117	0.844	1.163	0.843	1.211	0.848	1.215
Natural gas pipeline gas consumption	0.944	1.010	0.942	1.049	0.941	1.068	0.944	1.109	0.869	1.063

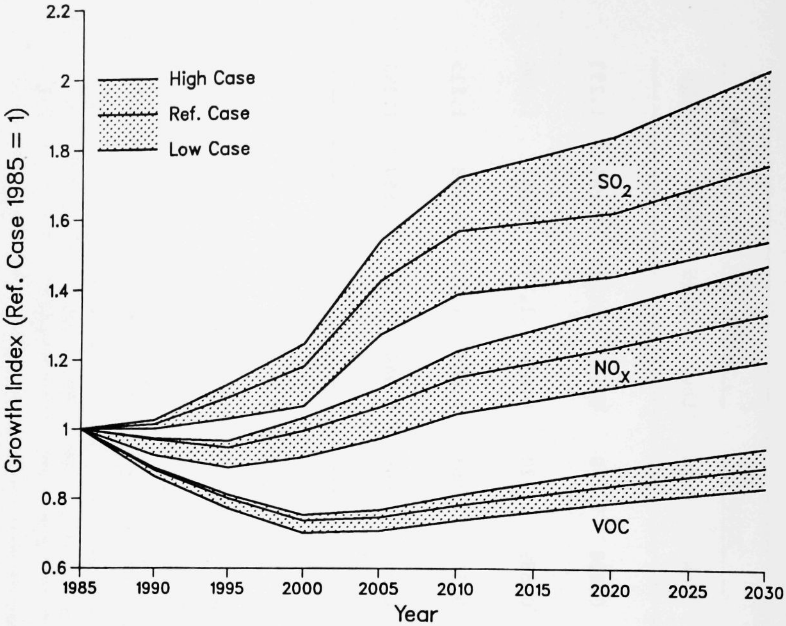

FIGURE 9 Growth Indexes of Pollutants under Three Scenarios [Preliminary projections using test data based on NEPP-5]

6 CONCLUSIONS

This report has described the testing of the Transportation Energy and Emissions Modeling System (TEEMS). The process by which demographic, economic, and technological data are compiled was discussed; this was followed by the activity regionalization procedure and emissions computations. It is the purpose of this report only to document the modeling process and the results of the 1985 test runs. However, the following general conclusions are offered:

- The TEEMS is sensitive to demographic and economic driver data. The magnitudes of changes in personal income, households, and number of workers for the test runs were insufficient to cause substantial changes in the amount of personal travel (nor, consequently, in the resulting VOC emissions).

- The TEEMS produced estimates of automobile VMT similar to estimates by DRI and lower than estimates by two other sources. Such variations are attributable to differences in demographic, economic, and technological inputs to the models, as well as to differences in modeling approach.

- The test results reflect the impact of current emissions regulations in achieving reductions in VOC and NO_x. The results also indicate that continued growth in transportation activity would reverse the present trend toward lower levels of emissions from transportation sources.

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APPENDIX A:

GLOSSARY OF INITIALISMS

APPENDIX A:

GLOSSARY OF INITIALISMS

ANL	Argonne National Laboratory
BEA	Bureau of Economic Analysis (U.S. Department of Commerce)
CARB	California Air Resources Board
CTS	Commodity Transportation Survey
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPTAM	Disaggregate Personal Transportation Activity Module
DRI	Data Resources, Inc.
DVSAM	Disaggregate Vehicle Stock Allocation Module
EEA	Energy and Environmental Analysis, Inc.
EIA	Energy Information Administration (DOE)
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration (DOT)
FHWA	Federal Highway Administration (DOT)
FRATE3	Freight-Responsive Accounting for Transportation Energy, Version 3
HDDT	Heavy-duty diesel-powered truck
HDDV	Heavy-duty diesel-powered vehicle
HDGT	Heavy-duty gasoline-powered truck
HDGV	Heavy-duty gasoline-powered vehicle
LDT	Light-duty truck
LDDT	Light-duty diesel-powered truck
LDGT	Light-duty gasoline-powered truck
LDV	Light-duty vehicle (automobile)
LTO	Landing/takeoff
NAPAP	National Acid Precipitation Assessment Program
NEDS	National Emission Data Survey
NEPP-5	National Energy Policy Plan 5
NO_x	Oxides of nitrogen
ORNL	Oak Ridge National Laboratory
POINTS	Passenger-Oriented Intercity Network Travel Simulation
scf	Standard cubic foot
SIC	Standard Industrial Classification
SMSA	Standard Metropolitan Statistical Area
STCC	Standard Transportation Commodity Classification
TAPCUT	Technology Assessment of Productive Conservation in Urban Transportation
TEEMS	Transportation Energy and Emissions Modeling System
TG-I	Task Group I, "Emissions and Controls"
TIUS	Truck Inventory and Use Survey
TMT	Ton-miles of travel
VMT	Vehicle-miles of travel
VOC	Volatile organic compound

APPENDIX B:

MOBILE3 AND AP-42 FACTORS

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##########################################################################
####                                                                  ####
####   #######   #######   #######    ##     ##     ####              ####
####      #      #         #         # #  #  #     #    #             ####
####      #      #         #        #    ##   #    #                  ####
####      #      #######   ####### #     ##    #     #                ####
####      #      #         #       #           #      #               ####
####      #      #         #       #           #   #   #              ####
####      #      #######   ####### #           #    ####              ####
####                                                                  ####
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THIS FILE CONTAINS THE MOBILE3 AND AP-42 FACTORS TO BE USED WITH THE      ********
ACTIVITY TOTALS FOR TRANSPORTATION DEVELOPED FOR 1990, 1995, 2000,        ********
2005, 2010, 2020 AND 2030.   THE COMPLETE SET OF ON-HIGHWAY FACTORS       ********
IS LISTED ALPHABETICALLY BY STATE FOR FORECAST YEARS.   FROM 2010 ONWARD********
THERE IS NO CHANGE IN HIGHWAY VEHICULAR EMISSION FACTORS PER MILE OF      ********
TRAVEL.  FOR EACH STATE, THERE ARE 10 LINES (5 YRS X 2 POLLUTANTS)        ********
OF MOBILE3-RELATED DATA.  THE DATA ARE PRESENTED IN THIS ORDER:           ********
STATE ABBREVIATION, FORECAST YEAR, POLLUTANT, LDV LOCAL TRAVEL FACTOR,    ********
LDV INTERCITY TRAVEL FACTOR (EACH WEIGHTED ACCORDING TO DIESEL SHARE      ********
FORECASTED BY DVSAM), LDGT LOCAL FACTOR, LDGT INTERCITY FACTOR, LDDT      ********
LOCAL FACTOR, LDDT INTERCITY FACTOR; HDG FACTOR AND HDD FACTOR (EACH      ********
OF THESE LAST WEIGHTED ACCORDING TO PROPORTION OF TRAVEL AT LOCAL AND     ********
INTERCITY SPEEDS). LINE FORMAT IS 3A5, 8F6.2.  SO2 EMISSION FACTORS ARE   ********
REPORTED ONCE BY YEAR AT THE END OF THESE STATE REPORTS BECAUSE THEY      ********
DO NOT VARY BY STATE (CLIMATE) IN ANY YEAR. THE ONE-LINE-PER-YEAR FOR-    ********
MAT IS A4, 5(A4,F6.3).  THESE FACTORS DO NOT DIFFERENTIATE BETWEEN LOCAL********
AND INTERCITY TRAVEL.  FOLLOWING THESE ARE THE OFF-HIGHWAY EMISSION       ********
FACTORS FROM AP-42, APPLICABLE IN ALL STATES BY FORECAST YEAR AS          ********
NOTED.  FACTORS APPEAR IN THIS ORDER: LOCOMOTIVE (YEAR, POLLUTANT,        ********
SWITCHING OPERATION FACTOR, LINE-HAUL OPERATION FACTOR--BOTH IN           ********
POUNDS PER THOUSAND GALLONS OF FUEL--WITH SO2 FACTOR CONSTANT AT          ********
57 LB FOR ALL YEARS AND BOTH MODES), AIRCRAFT (ONE LINE PER               ********
POLLUTANT FOR, RESPECTIVELY, COMMERCIAL, GENERAL, AND MILITARY            ********
AVIATION IN POUNDS OF POLLUTANT PER LTO CYCLE), MARINE VESSEL             ********
(ONE LINE OF THREE FACTORS FOR DIESEL MOTORSHIP, STEAMSHIP DISTILLATE     ********
BUNKER FUEL, AND RESIDUAL FUEL COMBUSTION--2 SETS--RESPECTIVELY), AND     ********
GAS PIPELINE (VOC, NO2 AND SO2 IN POUNDS OF POLLUTANT PER MILLION SCF).  ********
                                                                          ********
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AL	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
AL	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
AL	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
AL	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
AL	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
AL	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
AL	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
AL	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
AL	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
AL	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
AL	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
AL	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71

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AZ	1985	VOC	3.55	1.82	8.06	3.47	0.79	0.27	15.30	2.59
AZ	1985	NO2	1.98	1.87	3.41	3.26	1.98	1.67	5.19	23.10
AZ	1990	VOC	2.36	1.10	5.86	2.19	0.77	0.26	8.08	1.93
AZ	1990	NO2	1.50	1.23	3.25	2.79	2.08	1.75	4.77	18.62
AZ	1995	VOC	1.82	0.82	4.27	1.50	0.82	0.27	5.99	1.64
AZ	1995	NO2	1.35	0.97	2.97	2.27	2.00	1.69	4.37	14.45
AZ	2000	VOC	1.65	0.75	3.30	1.20	0.86	0.29	5.34	1.53
AZ	2000	NO2	1.33	0.92	2.72	1.91	1.99	1.68	4.18	13.13
AZ	2005	VOC	1.61	0.74	3.00	1.13	0.88	0.30	5.12	1.49
AZ	2005	NO2	1.33	0.93	2.60	1.74	1.99	1.69	4.12	12.80
AZ	2010	VOC	1.61	0.73	2.98	1.13	0.89	0.30	5.10	1.49
AZ	2010	NO2	1.33	0.93	2.58	1.72	2.00	1.69	4.10	12.71
AR	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
AR	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
AR	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
AR	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
AR	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
AR	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
AR	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
AR	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
AR	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
AR	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
AR	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
AR	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71
CA	1985	VOC	2.29	1.07	2.58	1.00	0.69	0.23	7.65	2.31
CA	1985	NO2	1.68	1.83	1.65	1.92	1.60	1.35	6.91	19.91
CA	1990	VOC	1.35	0.58	1.66	0.58	0.56	0.19	5.52	2.07
CA	1990	NO2	1.16	1.30	1.13	1.35	1.39	1.17	5.43	16.01
CA	1995	VOC	1.08	0.45	1.27	0.42	0.50	0.17	5.25	1.99
CA	1995	NO2	0.96	1.05	0.94	1.14	1.36	1.15	4.96	14.85

CA	2000	VOC	1.02	0.42	1.15	0.38	0.49	0.17	5.34	1.96
CA	2000	NO2	0.91	0.98	0.87	1.04	1.36	1.15	4.83	14.56
CA	2005	VOC	1.02	0.42	1.14	0.38	0.49	0.16	5.38	1.96
CA	2005	NO2	0.90	0.97	0.86	1.02	1.36	1.15	4.81	14.54
CA	2010	VOC	1.02	0.42	1.14	0.38	0.49	0.16	5.38	1.96
CA	2010	NO2	0.89	0.97	0.86	1.02	1.36	1.15	4.81	14.54
CZ										
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CO	1985	VOC	4.84	2.81	10.14	5.32	1.31	0.44	19.21	5.08
CO	1985	NO2	1.71	2.12	2.67	3.69	1.85	1.56	3.82	23.10
CO	1990	VOC	2.93	1.47	6.88	3.19	0.97	0.33	10.00	3.90
CO	1990	NO2	1.57	1.96	2.62	3.70	1.44	1.22	4.12	16.89
CO	1995	VOC	2.11	0.95	4.81	2.02	0.97	0.32	7.35	3.43
CO	1995	NO2	1.55	1.96	2.33	3.40	1.32	1.11	4.14	14.16
CO	2000	VOC	1.87	0.82	3.67	1.49	0.99	0.33	6.52	3.26
CO	2000	NO2	1.55	1.97	2.07	3.11	1.30	1.10	4.06	13.35
CO	2005	VOC	1.82	0.80	3.35	1.37	1.02	0.34	6.24	3.19
CO	2005	NO2	1.55	1.98	1.93	2.92	1.31	1.10	4.04	13.16
CO	2010	VOC	1.81	0.80	3.33	1.37	1.03	0.34	6.21	3.19
CO	2010	NO2	1.55	1.98	1.91	2.90	1.31	1.11	4.03	13.10
CT	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
CT	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
CT	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
CT	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
CT	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
CT	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
CT	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
CT	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
CT	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
CT	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
CT	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
CT	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
DE	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
DE	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
DE	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
DE	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
DE	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
DE	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
DE	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
DE	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
DE	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
DE	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
DE	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
DE	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71

DC	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
DC	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
DC	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
DC	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
DC	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
DC	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
DC	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
DC	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
DC	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
DC	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
DC	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
DC	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71
FL	1985	VOC	3.55	1.82	8.06	3.47	0.79	0.27	15.30	2.59
FL	1985	NO2	1.70	1.62	2.93	2.80	1.98	1.67	5.19	23.10
FL	1990	VOC	2.36	1.10	5.86	2.19	0.77	0.26	8.08	1.93
FL	1990	NO2	1.30	1.05	2.79	2.39	2.08	1.75	4.77	18.62
FL	1995	VOC	1.82	0.82	4.27	1.50	0.82	0.27	5.99	1.64
FL	1995	NO2	1.16	0.84	2.55	1.95	2.00	1.69	4.37	14.45
FL	2000	VOC	1.65	0.75	3.30	1.20	0.86	0.29	5.34	1.53
FL	2000	NO2	1.15	0.80	2.34	1.64	1.99	1.68	4.18	13.13
FL	2005	VOC	1.61	0.74	3.00	1.13	0.88	0.30	5.12	1.49
FL	2005	NO2	1.15	0.80	2.23	1.49	1.99	1.69	4.12	12.80
FL	2010	VOC	1.61	0.73	2.98	1.13	0.89	0.30	5.10	1.49
FL	2010	NO2	1.15	0.80	2.22	1.48	2.00	1.69	4.10	12.71
GA	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
GA	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
GA	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
GA	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
GA	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
GA	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
GA	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
GA	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
GA	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
GA	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
GA	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
GA	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71
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ID	1985	VOC	4.84	2.81	10.14	5.32	1.31	0.44	19.21	5.08
ID	1985	NO2	1.71	2.12	2.67	3.69	1.85	1.56	3.82	23.10
ID	1990	VOC	2.93	1.47	6.88	3.19	0.97	0.33	10.00	3.90
ID	1990	NO2	1.57	1.96	2.62	3.70	1.44	1.22	4.12	16.89
ID	1995	VOC	2.11	0.95	4.81	2.02	0.97	0.32	7.35	3.43
ID	1995	NO2	1.55	1.96	2.33	3.40	1.32	1.11	4.14	14.16
ID	2000	VOC	1.87	0.82	3.67	1.49	0.99	0.33	6.52	3.26
ID	2000	NO2	1.55	1.97	2.07	3.11	1.30	1.10	4.06	13.35
ID	2005	VOC	1.82	0.80	3.35	1.37	1.02	0.34	6.24	3.19
ID	2005	NO2	1.55	1.98	1.93	2.92	1.31	1.10	4.04	13.16
ID	2010	VOC	1.81	0.80	3.33	1.37	1.03	0.34	6.21	3.19
ID	2010	NO2	1.55	1.98	1.91	2.90	1.31	1.11	4.03	13.10
IL	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
IL	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
IL	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
IL	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
IL	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
IL	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
IL	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
IL	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
IL	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
IL	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
IL	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
IL	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
IN	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
IN	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
IN	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
IN	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
IN	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
IN	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
IN	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
IN	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
IN	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
IN	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
IN	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
IN	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
IA	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
IA	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
IA	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
IA	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
IA	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
IA	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
IA	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
IA	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
IA	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
IA	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
IA	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
IA	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71

KS	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.599
KS	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
KS	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
KS	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
KS	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
KS	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
KS	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
KS	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
KS	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
KS	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
KS	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
KS	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
KY	1985	VOC	3.49	1.78	8.00	3.40	0.79	0.27	14.95	2.59
KY	1985	NO2	2.03	1.90	3.44	3.24	1.98	1.67	5.51	23.10
KY	1990	VOC	2.30	1.08	5.78	2.13	0.77	0.26	7.87	1.93
KY	1990	NO2	1.61	1.30	3.38	2.86	2.08	1.75	5.38	18.62
KY	1995	VOC	1.77	0.81	4.19	1.47	0.82	0.27	5.83	1.64
KY	1995	NO2	1.48	1.07	3.18	2.41	2.00	1.69	5.03	14.45
KY	2000	VOC	1.60	0.75	3.22	1.19	0.86	0.29	5.20	1.53
KY	2000	NO2	1.46	1.03	2.97	2.09	1.99	1.68	4.83	13.13
KY	2005	VOC	1.57	0.74	2.93	1.13	0.88	0.30	4.99	1.49
KY	2005	NO2	1.46	1.03	2.86	1.93	1.99	1.69	4.78	12.80
KY	2010	VOC	1.57	0.73	2.91	1.13	0.89	0.30	4.96	1.49
KY	2010	NO2	1.45	1.03	2.84	1.91	2.00	1.69	4.74	12.71
LA	1985	VOC	3.52	1.80	8.03	3.43	0.79	0.27	15.13	2.59
LA	1985	NO2	1.87	1.76	3.18	3.02	1.98	1.67	5.35	23.10
LA	1990	VOC	2.33	1.09	5.82	2.16	0.77	0.26	7.97	1.93
LA	1990	NO2	1.45	1.17	3.08	2.62	2.08	1.75	5.07	18.62
LA	1995	VOC	1.80	0.82	4.23	1.48	0.82	0.27	5.91	1.64
LA	1995	NO2	1.32	0.95	2.86	2.18	2.00	1.69	4.70	14.45
LA	2000	VOC	1.63	0.75	3.26	1.19	0.86	0.29	5.27	1.53
LA	2000	NO2	1.30	0.91	2.65	1.86	1.99	1.68	4.50	13.13
LA	2005	VOC	1.59	0.74	2.97	1.13	0.88	0.30	5.05	1.49
LA	2005	NO2	1.30	0.92	2.54	1.71	1.99	1.69	4.45	12.80
LA	2010	VOC	1.59	0.73	2.94	1.13	0.89	0.30	5.03	1.49
LA	2010	NO2	1.30	0.92	2.53	1.69	2.00	1.69	4.42	12.71
ME	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
ME	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
ME	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
ME	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
ME	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
ME	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
ME	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
ME	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
ME	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
ME	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
ME	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
ME	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
MD	1985	VOC	3.52	1.80	8.03	3.43	0.79	0.27	15.13	2.59
MD	1985	NO2	1.87	1.76	3.18	3.02	1.98	1.67	5.35	23.10
MD	1990	VOC	2.33	1.09	5.82	2.16	0.77	0.26	7.97	1.93
MD	1990	NO2	1.45	1.17	3.08	2.62	2.08	1.75	5.07	18.62
MD	1995	VOC	1.80	0.82	4.23	1.48	0.82	0.27	5.91	1.64
MD	1995	NO2	1.32	0.95	2.86	2.18	2.00	1.69	4.70	14.45

MD	2000	VOC	1.63	0.75	3.26	1.19	0.86	0.29	5.27	1.53
MD	2000	NO2	1.30	0.91	2.65	1.86	1.99	1.68	4.50	13.13
MD	2005	VOC	1.59	0.74	2.97	1.13	0.88	0.30	5.05	1.49
MD	2005	NO2	1.30	0.92	2.54	1.71	1.99	1.69	4.45	12.80
MD	2010	VOC	1.59	0.73	2.94	1.13	0.89	0.30	5.03	1.49
MD	2010	NO2	1.30	0.92	2.53	1.69	2.00	1.69	4.42	12.71
MA	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
MA	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
MA	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
MA	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
MA	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
MA	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
MA	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
MA	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
MA	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
MA	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
MA	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
MA	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
MI	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
MI	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
MI	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
MI	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
MI	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
MI	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
MI	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
MI	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
MI	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
MI	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
MI	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
MI	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
MN	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
MN	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
MN	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
MN	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
MN	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
MN	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
MN	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
MN	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
MN	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
MN	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
MN	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
MN	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
MS	1985	VOC	3.52	1.80	8.03	3.43	0.79	0.27	15.13	2.59
MS	1985	NO2	1.87	1.76	3.18	3.02	1.98	1.67	5.35	23.10
MS	1990	VOC	2.33	1.09	5.82	2.16	0.77	0.26	7.97	1.93
MS	1990	NO2	1.45	1.17	3.08	2.62	2.08	1.75	5.07	18.62
MS	1995	VOC	1.80	0.82	4.23	1.48	0.82	0.27	5.91	1.64
MS	1995	NO2	1.32	0.95	2.86	2.18	2.00	1.69	4.70	14.45
MS	2000	VOC	1.63	0.75	3.26	1.19	0.86	0.29	5.27	1.53
MS	2000	NO2	1.30	0.91	2.65	1.86	1.99	1.68	4.50	13.13
MS	2005	VOC	1.59	0.74	2.97	1.13	0.88	0.30	5.05	1.49
MS	2005	NO2	1.30	0.92	2.54	1.71	1.99	1.69	4.45	12.80
MS	2010	VOC	1.59	0.73	2.94	1.13	0.89	0.30	5.03	1.49
MS	2010	NO2	1.30	0.92	2.53	1.69	2.00	1.69	4.42	12.71

MO	1985	VOC	3.52	1.80	8.03	3.43	0.79	0.27	15.13	2.59
MO	1985	NO2	1.87	1.76	3.18	3.02	1.98	1.67	5.35	23.10
MO	1990	VOC	2.33	1.09	5.82	2.16	0.77	0.26	7.97	1.93
MO	1990	NO2	1.45	1.17	3.08	2.62	2.08	1.75	5.07	18.62
MO	1995	VOC	1.80	0.82	4.23	1.48	0.82	0.27	5.91	1.64
MO	1995	NO2	1.32	0.95	2.86	2.18	2.00	1.69	4.70	14.45
MO	2000	VOC	1.63	0.75	3.26	1.19	0.86	0.29	5.27	1.53
MO	2000	NO2	1.30	0.91	2.65	1.86	1.99	1.68	4.50	13.13
MO	2005	VOC	1.59	0.74	2.97	1.13	0.88	0.30	5.05	1.49
MO	2005	NO2	1.30	0.92	2.54	1.71	1.99	1.69	4.45	12.80
MO	2010	VOC	1.59	0.73	2.94	1.13	0.89	0.30	5.03	1.49
MO	2010	NO2	1.30	0.92	2.53	1.69	2.00	1.69	4.42	12.71
MT	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
MT	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
MT	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
MT	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
MT	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
MT	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
MT	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
MT	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
MT	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
MT	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
MT	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
MT	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
NE	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
NE	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
NE	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
NE	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
NE	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
NE	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
NE	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
NE	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
NE	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
NE	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
NE	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
NE	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
NV	1985	VOC	4.84	2.81	10.14	5.32	1.31	0.44	19.21	5.08
NV	1985	NO2	1.71	2.12	2.67	3.69	1.85	1.56	3.82	23.10
NV	1990	VOC	2.93	1.47	6.88	3.19	0.97	0.33	10.00	3.90
NV	1990	NO2	1.57	1.96	2.62	3.70	1.44	1.22	4.12	16.89
NV	1995	VOC	2.11	0.95	4.81	2.02	0.97	0.32	7.35	3.43
NV	1995	NO2	1.55	1.96	2.33	3.40	1.32	1.11	4.14	14.16
NV	2000	VOC	1.87	0.82	3.67	1.49	0.99	0.33	6.52	3.26
NV	2000	NO2	1.55	1.97	2.07	3.11	1.30	1.10	4.06	13.35
NV	2005	VOC	1.82	0.80	3.35	1.37	1.02	0.34	6.24	3.19
NV	2005	NO2	1.55	1.98	1.93	2.92	1.31	1.10	4.04	13.16
NV	2010	VOC	1.81	0.80	3.33	1.37	1.03	0.34	6.21	3.19
NV	2010	NO2	1.55	1.98	1.91	2.90	1.31	1.11	4.03	13.10
NH	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
NH	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
NH	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
NH	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
NH	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
NH	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45

NH	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
NH	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
NH	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
NH	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
NH	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
NH	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
NJ	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
NJ	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
NJ	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
NJ	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
NJ	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
NJ	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
NJ	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
NJ	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
NJ	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
NJ	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
NJ	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
NJ	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
NM	1985	VOC	3.55	1.82	8.06	3.47	0.79	0.27	15.30	2.59
NM	1985	NO2	1.98	1.87	3.41	3.26	1.98	1.67	5.19	23.10
NM	1990	VOC	2.36	1.10	5.86	2.19	0.77	0.26	8.08	1.93
NM	1990	NO2	1.50	1.23	3.25	2.79	2.08	1.75	4.77	18.62
NM	1995	VOC	1.82	0.82	4.27	1.50	0.82	0.27	5.99	1.64
NM	1995	NO2	1.35	0.97	2.97	2.27	2.00	1.69	4.37	14.45
NM	2000	VOC	1.65	0.75	3.30	1.20	0.86	0.29	5.34	1.53
NM	2000	NO2	1.33	0.92	2.72	1.91	1.99	1.68	4.18	13.13
NM	2005	VOC	1.61	0.74	3.00	1.13	0.88	0.30	5.12	1.49
NM	2005	NO2	1.33	0.93	2.60	1.74	1.99	1.69	4.12	12.80
NM	2010	VOC	1.61	0.73	2.98	1.13	0.89	0.30	5.10	1.49
NM	2010	NO2	1.33	0.93	2.58	1.72	2.00	1.69	4.10	12.71
NY	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
NY	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
NY	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
NY	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
NY	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
NY	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
NY	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
NY	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
NY	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
NY	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
NY	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
NY	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
NC	1985	VOC	3.52	1.80	8.03	3.43	0.79	0.27	15.13	2.59
NC	1985	NO2	1.87	1.76	3.18	3.02	1.98	1.67	5.35	23.10
NC	1990	VOC	2.33	1.09	5.82	2.16	0.77	0.26	7.97	1.93
NC	1990	NO2	1.45	1.17	3.08	2.62	2.08	1.75	5.07	18.62
NC	1995	VOC	1.80	0.82	4.23	1.48	0.82	0.27	5.91	1.64
NC	1995	NO2	1.32	0.95	2.86	2.18	2.00	1.69	4.70	14.45
NC	2000	VOC	1.63	0.75	3.26	1.19	0.86	0.29	5.27	1.53
NC	2000	NO2	1.30	0.91	2.65	1.86	1.99	1.68	4.50	13.13
NC	2005	VOC	1.59	0.74	2.97	1.13	0.88	0.30	5.05	1.49
NC	2005	NO2	1.30	0.92	2.54	1.71	1.99	1.69	4.45	12.80
NC	2010	VOC	1.59	0.73	2.94	1.13	0.89	0.30	5.03	1.49
NC	2010	NO2	1.30	0.92	2.53	1.69	2.00	1.69	4.42	12.71

ND	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
ND	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
ND	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
ND	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
ND	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
ND	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
ND	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
ND	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
ND	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
ND	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
ND	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
ND	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
OH	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
OH	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
OH	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
OH	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
OH	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
OH	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
OH	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
OH	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
OH	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
OH	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
OH	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
OH	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
OK	1985	VOC	3.53	1.81	8.04	3.45	0.79	0.27	15.22	2.59
OK	1985	NO2	1.92	1.81	3.30	3.14	1.98	1.67	5.27	23.10
OK	1990	VOC	2.35	1.09	5.84	2.17	0.77	0.26	8.03	1.93
OK	1990	NO2	1.48	1.20	3.17	2.71	2.08	1.75	4.92	18.62
OK	1995	VOC	1.81	0.82	4.25	1.49	0.82	0.27	5.95	1.64
OK	1995	NO2	1.33	0.96	2.92	2.22	2.00	1.69	4.54	14.45
OK	2000	VOC	1.64	0.75	3.28	1.20	0.86	0.29	5.31	1.53
OK	2000	NO2	1.32	0.92	2.69	1.89	1.99	1.68	4.34	13.13
OK	2005	VOC	1.60	0.74	2.98	1.13	0.88	0.30	5.09	1.49
OK	2005	NO2	1.32	0.92	2.57	1.72	1.99	1.69	4.28	12.80
OK	2010	VOC	1.60	0.73	2.96	1.13	0.89	0.30	5.06	1.49
OK	2010	NO2	1.31	0.92	2.55	1.71	2.00	1.69	4.26	12.71
OR	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
OR	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
OR	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
OR	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
OR	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
OR	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
OR	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
OR	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
OR	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
OR	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
OR	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
OR	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
PA	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
PA	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
PA	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
PA	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
PA	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
PA	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45

PA	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
PA	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
PA	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
PA	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
PA	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
PA	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
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RI	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
RI	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
RI	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
RI	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
RI	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
RI	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
RI	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
RI	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
RI	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
RI	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
RI	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
RI	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
SC	1985	VOC	3.53	1.81	8.04	3.45	0.79	0.27	15.22	2.59
SC	1985	NO2	1.92	1.81	3.30	3.14	1.98	1.67	5.27	23.10
SC	1990	VOC	2.35	1.09	5.84	2.17	0.77	0.26	8.03	1.93
SC	1990	NO2	1.48	1.20	3.17	2.71	2.08	1.75	4.92	18.62
SC	1995	VOC	1.81	0.82	4.25	1.49	0.82	0.27	5.95	1.64
SC	1995	NO2	1.33	0.96	2.92	2.22	2.00	1.69	4.54	14.45
SC	2000	VOC	1.64	0.75	3.28	1.20	0.86	0.29	5.31	1.53
SC	2000	NO2	1.32	0.92	2.69	1.89	1.99	1.68	4.34	13.13
SC	2005	VOC	1.60	0.74	2.98	1.13	0.88	0.30	5.09	1.49
SC	2005	NO2	1.32	0.92	2.57	1.72	1.99	1.69	4.28	12.80
SC	2010	VOC	1.60	0.73	2.96	1.13	0.89	0.30	5.06	1.49
SC	2010	NO2	1.31	0.92	2.55	1.71	2.00	1.69	4.26	12.71
SD	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
SD	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
SD	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
SD	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
SD	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
SD	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
SD	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
SD	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
SD	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
SD	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
SD	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
SD	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71

TN	1985	VOC	3.53	1.81	8.04	3.45	0.79	0.27	15.22	2.59
TN	1985	NO2	1.92	1.81	3.30	3.14	1.98	1.67	5.27	23.10
TN	1990	VOC	2.35	1.09	5.84	2.17	0.77	0.26	8.03	1.93
TN	1990	NO2	1.48	1.20	3.17	2.71	2.08	1.75	4.92	18.62
TN	1995	VOC	1.81	0.82	4.25	1.49	0.82	0.27	5.95	1.64
TN	1995	NO2	1.33	0.96	2.92	2.22	2.00	1.69	4.54	14.45
TN	2000	VOC	1.64	0.75	3.28	1.20	0.86	0.29	5.31	1.53
TN	2000	NO2	1.32	0.92	2.69	1.89	1.99	1.68	4.34	13.13
TN	2005	VOC	1.60	0.74	2.98	1.13	0.88	0.30	5.09	1.49
TN	2005	NO2	1.32	0.92	2.57	1.72	1.99	1.69	4.28	12.80
TN	2010	VOC	1.60	0.73	2.96	1.13	0.89	0.30	5.06	1.49
TN	2010	NO2	1.31	0.92	2.55	1.71	2.00	1.69	4.26	12.71
TX	1985	VOC	3.55	1.82	8.06	3.47	0.79	0.27	15.30	2.59
TX	1985	NO2	1.84	1.74	3.17	3.03	1.98	1.67	5.19	23.10
TX	1990	VOC	2.36	1.10	5.86	2.19	0.77	0.26	8.08	1.93
TX	1990	NO2	1.40	1.14	3.02	2.59	2.08	1.75	4.77	18.62
TX	1995	VOC	1.82	0.82	4.27	1.50	0.82	0.27	5.99	1.64
TX	1995	NO2	1.25	0.90	2.76	2.11	2.00	1.69	4.37	14.45
TX	2000	VOC	1.65	0.75	3.30	1.20	0.86	0.29	5.34	1.53
TX	2000	NO2	1.24	0.86	2.53	1.77	1.99	1.68	4.18	13.13
TX	2005	VOC	1.61	0.74	3.00	1.13	0.88	0.30	5.12	1.49
TX	2010	NO2	1.24	0.86	2.41	1.61	1.99	1.69	4.12	12.80
TX	2010	VOC	1.61	0.73	2.98	1.13	0.89	0.30	5.10	1.49
TX	2005	NO2	1.24	0.86	2.40	1.60	2.00	1.69	4.10	12.71
UT	1985	VOC	4.84	2.81	10.14	5.32	1.31	0.44	19.21	5.08
UT	1985	NO2	1.71	2.12	2.67	3.69	1.85	1.56	3.82	23.10
UT	1990	VOC	2.93	1.47	6.88	3.19	0.97	0.33	10.00	3.90
UT	1990	NO2	1.57	1.96	2.62	3.70	1.44	1.22	4.12	16.89
UT	1995	VOC	2.11	0.95	4.81	2.02	0.97	0.32	7.35	3.43
UT	1995	NO2	1.55	1.96	2.33	3.40	1.32	1.11	4.14	14.16
UT	2000	VOC	1.87	0.82	3.67	1.49	0.99	0.33	6.52	3.26
UT	2000	NO2	1.55	1.97	2.07	3.11	1.30	1.10	4.06	13.35
UT	2005	VOC	1.82	0.80	3.35	1.37	1.02	0.34	6.24	3.19
UT	2005	NO2	1.55	1.98	1.93	2.92	1.31	1.10	4.04	13.16
UT	2010	VOC	1.81	0.80	3.33	1.37	1.03	0.34	6.21	3.19
UT	2010	NO2	1.55	1.98	1.91	2.90	1.31	1.11	4.03	13.10
VT	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
VT	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
VT	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
VT	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
VT	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
VT	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
VT	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
VT	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
VT	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
VT	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
VT	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
VT	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71
VA	1985	VOC	3.53	1.81	8.04	3.45	0.79	0.27	15.22	2.59
VA	1985	NO2	1.92	1.81	3.30	3.14	1.98	1.67	5.27	23.10
VA	1990	VOC	2.35	1.09	5.84	2.17	0.77	0.26	8.03	1.93
VA	1990	NO2	1.48	1.20	3.17	2.71	2.08	1.75	4.92	18.62
VA	1995	VOC	1.81	0.82	4.25	1.49	0.82	0.27	5.95	1.64
VA	1995	NO2	1.33	0.96	2.92	2.22	2.00	1.69	4.54	14.45

VA	2000	VOC	1.64	0.75	3.28	1.20	0.86	0.29	5.31	1.53
VA	2000	NO2	1.32	0.92	2.69	1.89	1.99	1.68	4.34	13.13
VA	2005	VOC	1.60	0.74	2.98	1.13	0.88	0.30	5.09	1.49
VA	2005	NO2	1.32	0.92	2.57	1.72	1.99	1.69	4.28	12.80
VA	2010	VOC	1.60	0.73	2.96	1.13	0.89	0.30	5.06	1.49
VA	2010	NO2	1.31	0.92	2.55	1.71	2.00	1.69	4.26	12.71
VI										
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VI										
VI										
WA	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
WA	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
WA	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
WA	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
WA	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
WA	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
WA	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
WA	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
WA	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
WA	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
WA	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
WA	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
WV	1985	VOC	3.86	1.82	8.74	3.46	0.79	0.27	15.34	2.59
WV	1985	NO2	2.13	2.00	3.59	3.41	1.98	1.67	5.64	23.10
WV	1990	VOC	2.63	1.11	6.45	2.18	0.77	0.26	8.20	1.93
WV	1990	NO2	1.69	1.37	3.58	3.02	2.08	1.75	5.50	18.62
WV	1995	VOC	2.07	0.84	4.80	1.52	0.82	0.27	6.14	1.64
WV	1995	NO2	1.57	1.14	3.39	2.56	2.00	1.69	5.13	14.45
WV	2000	VOC	1.89	0.77	3.78	1.24	0.86	0.29	5.50	1.53
WV	2000	NO2	1.55	1.10	3.17	2.23	1.99	1.68	4.92	13.13
WV	2005	VOC	1.85	0.76	3.47	1.18	0.88	0.30	5.29	1.49
WV	2005	NO2	1.55	1.10	3.05	2.06	1.99	1.69	4.87	12.80
WV	2010	VOC	1.84	0.76	3.45	1.18	0.89	0.30	5.27	1.49
WV	2010	NO2	1.55	1.10	3.03	2.04	2.00	1.69	4.84	12.71
WI	1985	VOC	4.33	1.86	9.66	3.52	0.79	0.27	15.74	2.59
WI	1985	NO2	2.22	2.11	3.76	3.58	1.98	1.67	5.77	23.10
WI	1990	VOC	3.08	1.14	7.29	2.24	0.77	0.26	8.56	1.93
WI	1990	NO2	1.80	1.45	3.78	3.20	2.08	1.75	5.60	18.62
WI	1995	VOC	2.48	0.87	5.58	1.57	0.82	0.27	6.47	1.64
WI	1995	NO2	1.67	1.21	3.61	2.73	2.00	1.69	5.23	14.45
WI	2000	VOC	2.27	0.80	4.52	1.29	0.86	0.29	5.84	1.53
WI	2000	NO2	1.65	1.17	3.38	2.38	1.99	1.68	5.02	13.13
WI	2005	VOC	2.22	0.79	4.19	1.23	0.88	0.30	5.63	1.49
WI	2005	NO2	1.66	1.17	3.25	2.20	1.99	1.69	4.97	12.80
WI	2010	VOC	2.20	0.79	4.17	1.23	0.89	0.30	5.61	1.49
WI	2010	NO2	1.66	1.17	3.23	2.18	2.00	1.69	4.94	12.71

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WY  1985  VOC  4.84  2.81 10.14  5.32  1.31  0.44 19.21  5.08
WY  1985  NO2  1.71  2.12  2.67  3.69  1.85  1.56  3.82 23.10
WY  1990  VOC  2.93  1.47  6.88  3.19  0.97  0.33 10.00  3.90
WY  1990  NO2  1.57  1.96  2.62  3.70  1.44  1.22  4.12 16.89
WY  1995  VOC  2.11  0.95  4.81  2.02  0.97  0.32  7.35  3.43
WY  1995  NO2  1.55  1.96  2.33  3.40  1.32  1.11  4.14 14.16
WY  2000  VOC  1.87  0.82  3.67  1.49  0.99  0.33  6.52  3.26
WY  2000  NO2  1.55  1.97  2.07  3.11  1.30  1.10  4.06 13.35
WY  2005  VOC  1.82  0.80  3.35  1.37  1.02  0.34  6.24  3.19
WY  2005  NO2  1.55  1.98  1.93  2.92  1.31  1.10  4.04 13.16
WY  2010  VOC  1.81  0.80  3.33  1.37  1.03  0.34  6.21  3.19
WY  2010  NO2  1.55  1.98  1.91  2.90  1.31  1.11  4.03 13.10
          ********************* SO2 *********************
1985 LDV 0.098 LGT 0.110 LDT 0.619 HDG 0.31  HDD 2.3
1990 LDV 0.082 LGT 0.089 LDT 0.569 HDG 0.28  HDT 2.0
1995 LDV 0.073 LGT 0.084 LDT 0.540 HDG 0.28  HDD 1.9
2000 LDV 0.066 LGT 0.078 LDT 0.514 HDG 0.27  HDD 1.8
2005 LDV 0.064 LGT 0.074 LDT 0.472 HDG 0.27  HDD 1.7
2010 LDV 0.063 LGT 0.070 LDT 0.454 HDG 0.26  HDD 1.7
2020 LDV 0.058 LGT 0.064 LDT 0.425 HDG 0.26  HDD 1.6
******************** LOCOMOTIVES ************************
1985 VOC 182  93 NO2 298 371 SO2  57  57
1990 VOC 179  91 NO2 310 374 SO2  57  57
1995 VOC 177  89 NO2 322 377 SO2  57  57
2000 VOC 175  86 NO2 334 381 SO2  57  57
2005 VOC 172  84 NO2 346 384 SO2  57  57
2010 VOC 170  82 NO2 358 387 SO2  57  57
2020 VOC 168  80 NO2 370 390 SO2  57  57
2030 VOC 168  80 NO2 370 390 SO2  57  57
******************** AIRCRAFT ********************
     COMMERCIAL    GENERAL   MILITARY
    SHORT   LONG
       RUNWAY
 VOC 11.37   31.46    1.29     25.00
 NO2 24.51   32.76    0.25     14.50
 SO2  2.68    3.17    0.07      1.50
**************** MARINE VESSELS ********************
DIESEL POWER
  52 270  27
DISTILLATE BUNKER
   3  24  27
RESIDUAL 1990-2005
 1.5  50 318
RESIDUAL 2005-
 1.5  50 477
**************** PIPELINE ******************
   40 1000  0.6
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